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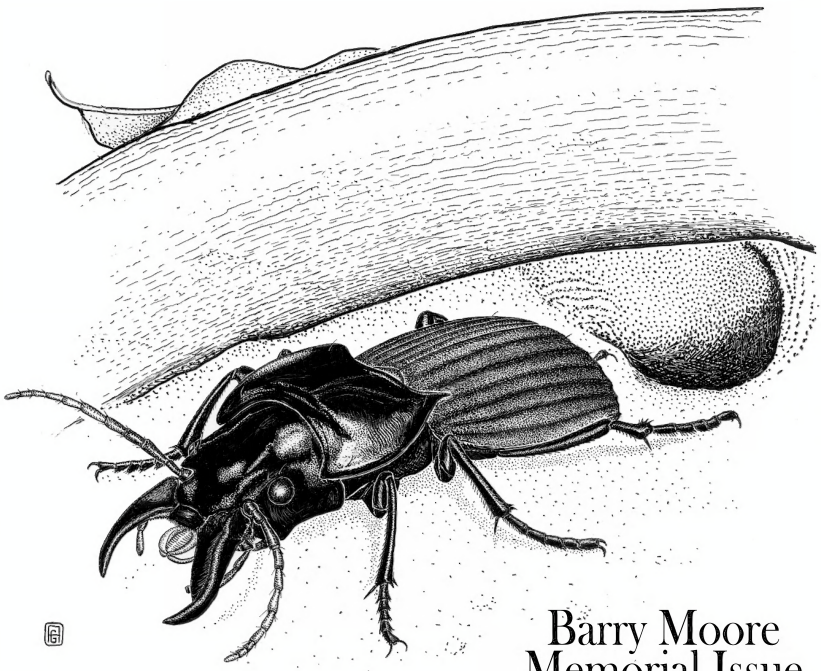

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BARRY PHILIP MOORE, 1925-2015, COLEOPTERIST, CHEMIST AND NATURAL HISTORIAN

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Abstract

Barry Moore was an English-born entomologist and biochemist who spent part of his career as an insecticide chemist and avid amateur collector in England before migrating to Australia, at age 33 in 1958, to eventually spend a brilliant career with CSIRO Division of Entomology researching chemical aspects of insect behaviour. In his private life he collected and studied Coleoptera and became a world authority on the Carabidae. Most of his collection passed to the Australian National Insect Collection.

Introduction

This special issue of *Australian Entomologist* is published in memory of the life of Barry Philip Moore, who was born in England on May 2, 1925 and died at Bermagui, New South Wales on November 16, 2015. He had a dual life in many respects. He spent the first third of his 90 years in the UK as a chemist by training and as an enthusiastic amateur entomologist for recreation, mixing with a band of gentleman naturalists in those green woods and meadows, exploring an English fauna that was well known. At age 33 he came to Australia, where he married and was able to merge his interests in chemistry and entomology in an outstanding career with CSIRO and to pursue, in his private time, a relatively poorly known insect fauna in a drier and harsher Australian landscape.

There have been two published obituaries: a brief notice by Monteith (2016) and a longer piece by Barry's good friend George Rothschild (2016), as well as a summary of his career at the time of his retirement by his CSIRO colleague Barry Longstaff (1985). The last two dealt mostly with his work on insect chemistry, whereas the present work will concentrate more on his other entomological activities. Nevertheless, I have tried to compile all his publications across disciplines and across the continents where he worked, though some will inevitably have been missed. They are listed chronologically by author in Appendix 1 and numbered sequentially. For brevity, his own publications will be cited by number in the text, while publications other than his will be cited in the usual way and are listed in the 'References'. The genera and species he described are listed in Appendix 2.

British beginnings, education and employment

Barry Moore was born and grew up in Littlehampton, just west of Brighton on the south coast of England. Being a beachside town opposite the French coast, it was fortified against possible German landings and partly evacuated in 1940, meaning that Barry, at age 15, left to complete his schooling elsewhere in the UK. Despite an early interest in insects, he enrolled at Sheffield University to study chemistry, gaining BSc (1945) and PhD (1947).

Fig. 1. An undated photograph of a young Barry Moore, probably about the time he graduated from Oxford University in 1951 (Image courtesy of Hugh Moore).

He had fond feelings for his original university and its website records that he bequeathed Sheffield £19,041 in his will. His brilliance in chemistry at Sheffield earned him a prestigious Department of Scientific and Industrial Research scholarship to undertake a D. Phil. in alkaloid chemistry at Oxford University (residing at Jesus College) under the guidance of Sir Robert Robinson, a Nobel Prize-winning organic chemist and President of the Royal Society. He completed his D. Phil. in 1950 and in the same year gained a year-long, National Research Council of Canada post-doctoral fellowship to the Council's research centre in Ottawa, where he worked and published on plant alkaloids in collaboration with Lee Marion [18, 141, 142]. An undated photograph shows Barry at about this time of his life (Fig. 1).

On return to the UK in 1951, he was appointed to the DSIR Pest Infestation Laboratory at Slough, on the outskirts of London, where he remained until his departure to Australia in 1958, living for most of the time at Farnham in Surrey. His task at Slough was to work on insecticide biochemistry, especially synergistic and assay aspects of pyrethrins [31, 37, 138], but their group made an unusual discovery that allowed Barry to draw on his growing beetle expertise. He found that although females of some races of one of the grain pest beetles they used for trials, *Ptinus clavipes* Panzer, were parthenogenetic; the female needed male copulation for egg maturation to take place even though the introduced sperm played no part in the process. This was achieved even if the female was mated by males of other species of *Ptinus*. This remarkable discovery led to a publication in *Nature* [147] and Barry, ostensibly a biochemist, was sent to Stockholm to study types to clarify beetle taxonomy, following which he erected the name *mobilis* for this very curious race of a widespread pest species [40]. This bizarre reproduction, known as gynogenesis, is still being researched (Sanderson 2012) and is unique in the Coleoptera.

Amateur entomology and Society activity in the UK

As with many beginners, Barry Moore's first interests as a collector were butterflies and especially dragonflies. He joined both the Royal Entomological Society of London and the South London Entomological and Natural History Society (SLENHS) while he was at Sheffield University in 1946 and became a regular attender of meetings of the latter at Westminster in central London from about 1947 when he commenced at Oxford. The SLENHS held a gala "Annual Exhibition" of display cases of specimens submitted by members in the rooms of the Royal Society in Piccadilly and Barry's first contribution to this was in 1947 with 'a case of butterflies collected from 1945-1947 in Surrey, Middlesex and Somerset' (Anon. 1948). Next year he showed Lepidoptera, Odonata and Coleoptera collected on a holiday in Jersey and a new record of a dragonfly from the same trip became his second small scientific paper [20]. But his interests were broad and between 1946 and 1958 he published many short items in the semi-popular *Entomologist's Monthly Magazine* on dragonflies [20,22,27,29,33], hoverflies [19],

wasps [24], sucking bugs [25] and beetles other than Carabidae [23, 28, 30, 33]. The last [33] was a detailed study on carrion beetle succession using corpses of introduced North American grey squirrels being shot by gamekeepers near Oxford during his D. Phil. days.

His chemical expertise found outlet in his amateur collecting and he devised a method for preserving the colours of dragonfly specimens [26] that is still cited today, experimented with embedding insects in the then novel acrylic resin [144] and proposed the use of clear 'xylonite' plastic to replace card mounts for Coleoptera [21]. In 1952 he served on a committee of the SLENHS set up to investigate 'anaesthetising agents for moth traps'.

Barry Moore's lifelong interest in carabid beetles began in early summer 1954 when he undertook a month long collecting traverse, with fellow chemist-cum-insect collector W.J. LeQuesne, from the Atlantic coast to the Mediterranean along the French Pyrenees. He published a list of 100 species of Carabidae from that venture [32], describing them as 'my particular interest' and praising the value of a screwdriver for lifting stones. When I collected with Barry in Australia 30 years later he still carried a screwdriver as an essential collecting tool. During his remaining 4 years in England after the Pyrenees venture, his natural history work dealt almost entirely with the British Carabidae [34,35,36,38,39,41]. Before he finally left for Australia he drew a line under his British work by summarising the whole carabid fauna in two papers, one a full checklist of UK fauna [38] and the other a compilation of county records for all species [39], both of which are still much-cited standard references.

From about 1953 he became active in the management of the SLENHS, exhibiting a wide range of insects at meetings and, in March of that year, gave a lecture on his collecting in Canada during his post-doctoral visit. In 1954 he became their Librarian. He rarely missed their group excursions and led one himself to Eashing Moors in Surrey in 1956 (Fig. 2), the same year that he became Vice-President (Anon. 1956). In 1957 he was elected President of SLENHS at age 32, following in the footsteps of many distinguished and much older predecessors. His presidential address delivered on 23 January 1958 was a lengthy dissertation on the relationships of the tiger beetles [42] and was delivered just weeks before he left the UK permanently for a new life in Australia.

Arrival in Australia and his Melbourne interlude

Barry Moore arrived in Melbourne, Australia, in March 1958 to take up a position with the CSIRO Division of Industrial Chemistry and to become part of the recently established Phytochemical Survey of Australia, whose aim was to assay samples of native plants for useful chemicals. His background in alkaloid chemistry and, particularly, his post-doctoral work in Canada on plant alkaloids equipped him well for the task. But the beetles called and within weeks of his arrival he was collecting carabids on nearby Mt Donna

Buang and in April 1958 the Secretary of the SLENHS in London 'read extracts from a letter from Dr. B.P. Moore giving details of the entomological fauna of Australia'. He met local beetle collectors F.E. Wilson and E.T. Smith and also saw the National Museum of Victoria collection, which has crucial types of Australia carabids described by Laporte (Castelnau). His earliest papers on Australian Carabidae were based on his collections from those nearby Victorian mountains and were published in England [45, 46, 47, 49].

His plant chemistry work in Melbourne concerned aspects of the toxic plant *Ochrosia poweri* Bailey [10, 11, 15]. One of his co-workers in the Phytochemical Survey was Honor Crowley (née Hebbard), a botany graduate from University of Melbourne who worked on alkaloids of *Tournefourtia* and *Heliotropium.* She was two years older than Barry and had two sons, Hugh and Neil (8 and 10 years old) from a previous marriage to historian Frank Crowley, who became a flamboyant history professor at Universities of both WA and NSW. Soon chemistry of a different kind entered Barry and Honor's lives and they married, Barry becoming a devoted father to the boys who took his surname. After only two and a half years in Melbourne, another radical change was looming in Barry's life.

EASHING MOORS, SURREY 12 August 1956.
Left to right: F. Rumsey, Dr B. P. Moore *(Leader)*, E. E .E. Trundell, F. M. Struthers, D. G. Hall, Mrs. Struthers, Mrs. Trundell, R. W. J. Uffen.

Fig. 2. Barry Moore, second from left, leading an excursion of the South London Entomological and Natural History Society in Surrey, UK in 1956 (Plate 5, reproduced from Anon. 1956).

CSIRO Division of Entomology – chemistry and entomology merge

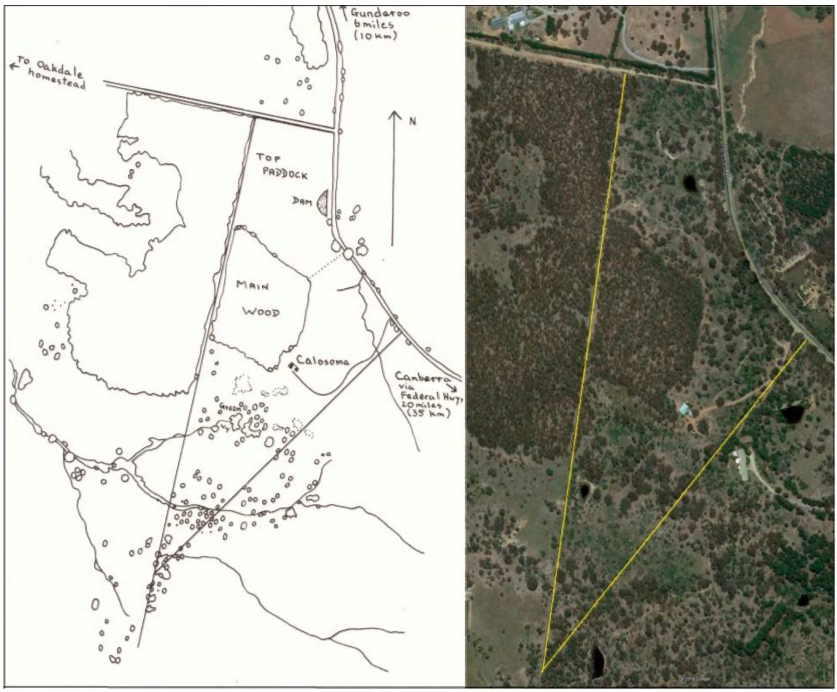
In 1960 the brilliant and influential Douglas Frew Waterhouse became Chief of the CSIRO Division of Entomology, based in the extensive Black Mountain Laboratories in Canberra. His background was in insect chemistry and he appointed Barry in the same year to head up a unit within the Division to investigate chemicals such as attractants, trail markers, defence secretions and pheromones employed by living insects. For Barry this was a dream come true since he could at last work directly with living insects and employ his consummate skills in organic chemistry. He moved to Canberra with his new family and went on to a brilliant 25-year career with the Division. Others have summarised these achievements (Longstaff 1985, Rothschild 2017) and I will give a brief summary of the spread of his activity and publications, much in collaboration with his long term colleague, Vance Brown. He pioneered work on trail pheromones and defence secretions in termites [3, 50, 59, 60, 66, 72]. He studied defence secretions and tissue chemicals in many insects, especially those showing warning colours, many of which he collected himself. Among beetles, these included staphylinids [2], tenebrionids [4], cantharids [5, 130], buprestids [6, 134], coccinellids [9], chrysomelids [70], tiger beetles [123], cerambycids [124, 126, 127] and lycids [133, 135]. Naturally, he made special efforts with the carabids and published substantial papers, including taxonomic implications, on their defense secretions [93, 132, 145], as well an overview of chromosome numbers in Australian carabids [13]. Among the other insects orders he studied defense chemicals of ants [8], cossid moths [7], butterflies [148] and other Lepidoptera [14, 16]. Importantly, he published world reviews of pheromones [62, 98], defense chemicals [136, 148] and termite biochemistry [74, 82]. In the field of pure chemistry he wrote up new chemical techniques and findings made during the course of the insect work [98, 125, 128, 129, 131].

When Barry took early retirement at age 60 in 1985, it was because 'he might be able to give greater emphasis to his field-related activities than is currently possible' (Longstaff 1985). He achieved that goal, although he had already gone a long way towards it by purchasing his own private bushland retreat.

Life on Forty Acres

After living in suburban Canberra for several years after settling there in 1960, Barry and Honor longed for a piece of their own bush to explore, restore and use as a weekend retreat. In 1968 they bought a degraded, 40-acre piece of farmland just west of Lake George and about 25 km north of the city. They set about replanting it and documenting the plants and animals and by 1971 they received approval to build a small house there. Honor worked part time in the Geography Department at Australian National University. She had just organised a very successful symposium on the biogeography of Torres Strait at ANU and was preparing to edit the papers into a special volume when tragedy struck and she was killed in a road accident on the

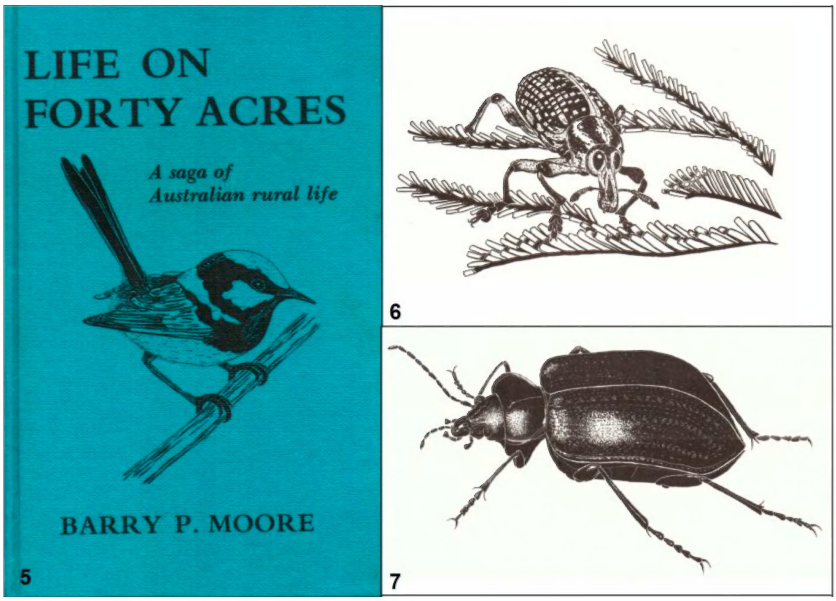
Monaro Highway south of Canberra. The volume was edited by her Professor and dedicated to her memory (Walker 1972). Barry decided to go ahead with the house and threw himself into years of hard work replanting the property and carefully documenting its fauna and flora, building a small museum at the house of all the species he encountered. He named the property 'Calosoma' after the large green caterpillar-eating carabid, *Calosoma schayeri* Erichson, which was common there.



Figs 3-4. Plan views of 'Calosoma' property, north of Canberra: (3) Barry Moore's sketch of the vegetation on 'Calosoma' soon after he bought it in 1968 (from *Life on Forty Acres*); (4) GoogleEarth image of the same property in 2015.

A few years later he was visited by an old friend from England, Norman Hickin, who had been on the Council of the SLENHS with Barry in the 1950s and followed Barry as president in 1958. The two were similar in many ways; both were essentially chemists by training and passionate naturalists by calling. Hickin was Rentokil's research director, in charge of pest control and chemical development, but also a leading authority on taxonomy and life histories of caddis flies. He had grown up beside the Wyre Forest in Worcestershire and had written a book on it (Hickin 1971), which had become a bestselling classic in that special English genre of books that explore the natural history of a local area in detail. Hickin had illustrated the

book himself with scores of black and white drawing of the plants, vertebrates and insects, using the then new method of scraperboard as his medium. After seeing how Barry had come to know and understand almost all forms of life on his property, Hickin urged him to write a similar book on 'Calosoma'. Barry took on the suggestion, mastered the same scraperboard technique and published in 1978 his own 'English-style' book [91] *Life on Forty Acres,* dedicated to Honor 'who saw only the beginnings'. In it he has a sketch map of the property and the vegetation in the 1970s. Comparing that with an aerial image of the property in 2015 (Figs 3-4) shows how successful were his efforts in restoration. The book has detailed treatment of many of the insects of all groups on the property, many of them beautifully illustrated (Figs 5-7). The property has stayed in the family and is now registered as a Wildlife Sanctuary in NSW under the Wildlife Land Trust. Barry's museum and voucher insect collection remain in the house.



Figs 5-7. Barry Moore's 1978 book *Life on Forty Acres*: (5) front cover; (6) scraper board drawing of the Botany Bay Diamond Beetle, *Chrysolophus spectabilis* (Fabricius); (7) scraper board drawing of *Calosoma schayeri* Erichson.

Carabid taxonomy, including cave beetles

When Barry Moore arrived in Australia in 1958 there had been little carabid taxonomy done on the local fauna since the death of prolific resident carabid worker, T.G. Sloane, in 1932. But on the mountains north of Melbourne, where Barry headed for his first taste of Australian carabids, there had been a

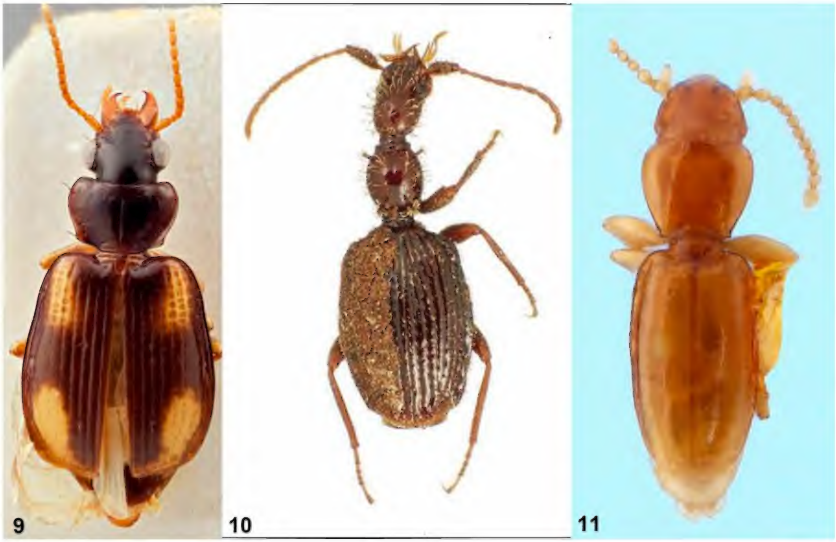
world-famous carabid taxonomist turning rocks only weeks before him and who was to have considerable influence on Barry's carabid research in the near future. This was Philip J. Darlington Jr, professor of Zoology in the Museum for Comparative Zoology at Harvard University, an eminent biogeographer and the then authority on Carabidae for the Pacific region. He was reviewing the whole New Guinea fauna and was coming to the end of an 18-month collecting trip from Tasmania to the tip of Cape York, systematically collecting Australian Carabidae so that he could better understand the relationship between the faunas of NG and Australia (Darlington 1960). He made prodigious collections but Darlington himself was to publish on only a few 'low hanging fruit' from those collections, *e.g* the large, showy species of *Pamborus* Latreille, *Nurus* Motschulsky and *Trichosternus* Chaudoir (Darlington 1961 a, b) and others. We know that Barry visited the MCZ in October 1961 'to look at Carabidae' (Liebherr 2018) and would have met Darlington then. Darlington's Australian collections would have been a point of discussion. The end result must have been an agreement for Barry to study many of the groups of smaller carabids that Darlington did not intend to study. This gave Barry superlative collections to add to his own material and enabled him to go on and write substantial generic reviews of the Agonicini [(51)], Psydrini [(52)], Pterostichini [(61)] and Trechini [(77)], which still stand as exemplars of their time. In a 1985 homage to Darlington in a memorial volume [(106)], Barry recalled spending a year at Harvard in 1967, ostensibly on chemical work, but he admitted to spending much time with the MCZ collections and with Darlington himself.

Barry had a special interest in cave carabids and explored actively for them himself, even coordinating a caving expedition to New Caledonia in 1965-66. He described new and bizarre cave carabids from New Guinea [(92)], Tasmania [(90, 115)] and mainland Australia [(48, 56, 69, 86, 116, 122)], as well as writing several overview papers on cave insects [(12, 58, 76, 139)].

Larvae of carabids are difficult to find and to correlate with the adults, yet they have significant contribution to make towards understanding phylogeny. Barry Moore made larval discoveries of several Australian groups for which the larvae were unknown, including *Carenum* [(140)] and *Pamborus* [(64)] and recorded many others [(57, 63, 78, 81)]. 'Extraordinary' was the word he used for larvae of South African species of *Epomis* Bonelli that feed on the blood of amphibians [(75)].

In the last years of his taxonomic activity he concentrated on the carabids of Pacific Islands such as New Zealand [(96, 118)], Fiji [(120)], Norfolk Island [(105)] and Lord Howe Island [(113)], travelling to most of them himself. He was aggrieved at not being able to finish work he had started on the strange New Caledonian fauna but pleased to see others taking up the cause during his last years. Many patronyms have been erected honouring Barry Moore (Figs 9-11). Figure 8 shows him with his collection at home at age 55.

Fig. 8. Barry Moore with part of his collection in his Canberra home in 1980 (Photo by Allen Sundholm).



Figs 9-11. Some Carabidae named after Barry Moore: (9) *Barrymooreana quadrimaculatus* (Baehr, 1987) occurs in far north Queensland and New Guinea. It was initially attributed to the preoccupied name *Mooreana* Baehr, 1987, which was renamed *Barrymooreana* by Baehr (1997) (Photo Geoff Thompson, Queensland Museum); (10) *Cyphocoleus moorei* (Park and Will, 2008) is a bizarre, reduced-eye species from mountain rainforests of New Caledonia that coats it body with detritus. It was initially place in a new zuphiine genus *Atongolium* Park and Will, 2008 but was transferred to the odacanthine genus *Cyphocoleus* Chaudoir by Liebherr (2016) (image from Liebherr 2016): (11) *Parillaphanus mooreana* Baehr, 2018 is a blind species and the first of its tribe recorded from the Northern Territory (image from Baehr 2018).

Stag beetle taxonomy

Besides the Carabidae, Barry Moore had a special interest in the Lucanidae, probably engendered by an early discovery of a thriving population of *Lissotes grammicus* Lea at Clyde Mountain, which necessitated transfer to the genus *Lissapterus* Deyrolle [(53)]. A major discovery in Australian biogeography was his recognition that a stag beetle that collector Alan Walford-Huggins had sent him from high altitude rainforest at Mt Lewis in northern Queensland, in 1973, had close South American relationships [(89)], being first placed in the genus *Sphaenognathus* Buquet as *S. queenslandicus* Moore, 1978. Even more remarkable was the discovery of a second species on open forested tablelands in inland central Queensland, which Barry described in 2004 [(143)]. Both species are now assigned to a separate endemic genus, *Australognathus* Chalumeau & Brochier (Chalumeau and Brochier 1993).

Association with *Australian Entomologist*

When Barry Moore first arrived in Australia he published most of his faunistic papers in his old staple, the British *Entomologist's Monthly Magazine,* with some larger papers going to journals of the Royal Entomological Society of London. The *Australian Entomologist* was founded as a private enterprise by Max Moulds in 1973 under the name *Australian Entomological Magazine* and it was modelled very much on the *Entomologist's Monthly Magazine*, right down to the pink covers. Barry immediately started to publish his small papers in it and had 15 papers in it over the years, including seven after it transferred to ownership of the Entomological Society of Queensland in 1987. He was a strong supporter of the journal and once opined that he would have taken it on as a personal enterprise himself, if the Queensland society had not accepted Moulds' offer to transfer ownership.

It was this enthusiasm for the young journal that prompted him to publish his largest work in it. This was a 226 page book called *A Guide to the Beetles of South-Eastern Australia,* illustrated by scores of his delightful scraperboard drawings, hundreds of line drawings and some colour photographs. It was written progressively over sixteen years and published as a series of 12 pull-out fascicles inserted into the centre of normal issues of the journal. The first appeared in June 1980 and the last in October 1996. They were designed to be bound into a complete book with introductory chapters, key to families, individual family treatments and a final index.

Australian Entomological Society and Export Regulation 13A

The Australian Entomological Society (AES) was founded in 1965 (Fletcher and Monteith 2016) and its early days were difficult ones. Barry Moore served as Vice-President and Chairman of the national executive in 1973-74 and then as General Editor of the society's journal from 1975-1982. During his vice-presidency a contentious issue, about which Barry had very strong views, swept the Australian entomological community. In order to stop holotypes of Australian insects being exported from Australia, a new Regulation 13A of the *Customs Act* was proposed that would prevent export of insect specimens from Australia, except under a complex permit system that would only be available to entomologists working in institutions registered with the Commonwealth Government. Barry thought of his taxonomic studies as his private 'amateur' activity and it was clear that Regulation 13A would prevent him and other amateur students of insects in Australia from freely exchanging study specimens with their overseas colleagues and thus it was an infringement of basic scientific freedom. As Vice-President of AES he arranged for an opinion survey on the matter to be carried out of all Australian entomologists. The results showed that the great majority shared Barry's view and he wrote a scathing summary of the results in the News Bulletin of AES [(80)]. Despite this, the regulation, which had been

proposed by two important members of CSIRO Division of Entomology, came into force and caused great angst until it was watered down years later. Barry penned a cartoon which he sent to me as then Editor of the AES News Bulletin, parodying the role of those two proponents who were shown in wicked caricature. Barry had signed it 'WOG' and asked if I would consider publishing it anonymously. I didn't, but since 40 years have passed and the artist and his subjects are no longer with us, it seems appropriate to do so now, if only to show how strong feelings were about the issue at that time (Fig. 12).

Fig. 12. Cartoon prepared by Barry Moore in 1982, under the pseudonym 'WOG', depicting his view of the originators of the infamous Customs Regulation 13A.

Retirement and his Julatten Field Station

Soon after his retirement in 1985, Barry bought a virgin block of ten hectares of rainforest on the Julatten plateau in North Queensland, about 60 km north of Cairns. It was within half an hour's drive of the famous Mt Lewis forests where the remarkable *Australognathus* stag beetle had been collected, as well a wealth of interesting Carabidae. His rainforest block had no clearing for a house but the cleared farmland next door was owned by John and Esther Brooks, John being the son of the late George Brooks, a beetle collector from Cairns whom Barry had known well. John and Esther allowed Barry to have a small cottage built on their land immediately adjacent to the edge of his own rainforest patch. This cottage became Barry's 'field station' and, for much of his retirement, he escaped Canberra's winter cold and its insect dearth by spending several winter months each year in residence at Julatten (Fig. 13).

Fig. 13. Barry Moore at his microscope desk in his 'field station' at Julatten, north Queensland (Photograph taken about 2005 by Esther Brooks).

Fig. 14. This case of Coleoptera from his rainforest property at Julatten was part of the Barry Moore collection which passed to the Australian National Insect Collection in 2018 (Photo by Cate Lemann).

He kept a good microscope and an insect cabinet there and systematically surveyed the beetles on his plot and built a reference collection. In the closing days of his Julatten period he had recorded 103 species of Carabidae and 353 species of other families from his block. In his later years he moved from Canberra to a warmer house on the coast at Bermagui and that was where he died at the age of 90.

Dispersal of the Barry Moore insect collection

Barry built up considerable collections, mostly by his own field work augmented by a limited amount of exchange for needed taxa with overseas colleagues. His main collection of Australian Carabidae was deposited with the CSIRO Australian National Insect Collection (ANIC) soon after he retired and his collection of Odonata went to ANIC in 1993. His non-Australian Carabidae and carabid larvae went to the Essig Museum at Berkeley University, California, headed by carabid specialist Kipling Will, in 2017. In 2018 the remainder of his non-carabid collection, comprising some 12,000 specimens, was deposited with ANIC and this included his Julatten collection (Fig. 14) and nine boxes of his important collection of Australian and exotic Lucanidae.

Acknowledgements

I am grateful to Esther Brooks, Allen Sundholm, Geoff Thompson, Kip Will, Cate Lemann and Hugh Moore for provision of photographs used in this account. Cate Lemann supplied information on the final deposition of Moore material with ANIC in 2018.

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APPENDIX 1

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APPENDIX 2

GENERA AND SPECIES DESCRIBED BY BARRY MOORE

Listed alphabetically under familes and geographic areas.

COLEOPTERA: CARABIDAE

AUSTRALIA

Acanthoferonia Moore, 1965
Acanthoferonia ferox Moore, 1965
Agonica victoriensis Moore, 1963
Agonochila signata Moore, 1963
Anomotarus subterraneus Moore, 1967
Anomotarus variegatus Moore, 1967
Austrotrechus Moore, 1972
Austrotrechus contortus Moore, 1972
Bothynotrechus Moore, 1972
Bothynotrechus lynx Moore, 1972
Conchitella Moore, 1962
Conchitella clivinoides Moore, 1962
Demetrida variolosa Moore, 1967
Demetrida metallica Moore, 1967
Eutrechopsis Moore, 1972
Eutrechopsis ovalis Moore, 1972
Eutrechus Moore, 1972
Eutrechus barringtonensis Moore, 1972
Feronista Moore, 1965 (= *Cerabilia* Laporte, 1867)
Feronista amaroides Moore, 1965
Feronista intermedius Moore, 1965
Feronista minor Moore, 1965
Goedetrechus Moore, 1972
Goedetrechus mendumae Moore, 1972
Goedetrechus parallelus Moore, 1972
Goedetrechus talpinus Moore, 1972
Idacarabus cordicollis Moore, 1967
Idacarabus longicollis Moore, 1978
Idacarabus punctipennis Moore, 1994
Laccocenus vicinus Moore, 2004
Lecanomerus limbatus Moore, 1967
Mecyclothorax storeyi Moore, 1984
Mecyclothorax lewisensis Moore, 1984
Megadromus (*Protodromus*) *eborensis* Moore, 1965
Mimanillus Moore, 1972
Mimanillus gracilis Moore, 1972
Mimotrechus Moore, 1972
Mimotrechus obscuroguttatus Moore, 1972

Mimotrechus scitulus Moore, 1972
Neonomius Moore, 1963
Notabax Moore, 1976
Notabax monteithi Moore, 1976
Notonomus aequabilis Moore, 1960
Notonomus atrodermis smithi Moore, 1961
Notonomus hamifer Moore, 1960
Notonomus obscurus Moore, 1963
Notospeophonus Moore, 1962
Notospeophonus castaneus Moore, 1962
Notospeophonus castaneus consobrinus Moore, 1964
Notospeophonus jasperensis vicinus Moore, 1964
Notospeophonus pallidus Moore, 1964
Nototarus freyi Moore, 1967
Nototarus magnus Moore, 1963
Nototrechus Moore, 1972
Nototrechus unicolor Moore, 1972
Percosoma substriatum Moore, 1960
Perileptus sloanei Moore, 1966
Perileptus westralis Moore, 1972
Phorticosomus rotundatus Moore, 1967
Pogonoschema pallipes Moore, 1972
Pogonoschema solidum Moore, 1972
Pogonus gilesi Moore, 1977
Pogonus grossi Moore, 1977
Pogonus variabilis Moore, 1991
Protodromus Moore, 1965
Pseudagonica Moore, 1960
Pseudagonica nitida Moore, 1960
Pseudagonica nitida orientalis Moore, 1963
Pterocyrtus cavicola Moore, 1994
Raphetis Moore, 1963
Raphetis darlingtoni Moore, 1963
Raphetis gracilis Moore, 1963
Sarticus (*Coronacanthus*) *obsolescens substriatus* Moore, 1963
Scopodes ocellatus Moore, 1963
Scopodes splendens Moore, 1963
Sitaphe Moore, 1963
Sitaphe rotundata Moore, 1963
Sloanella obscura Moore, 1983
Sloanella otwayensis Moore, 1960
Sloanella pallida Moore, 1972
Sloanella suavis Moore, 1972
Speotarus Moore, 1964
Speotarus lucifugus Moore, 1964

Speotarus princeps Moore, 1964
Speothalpius Moore, 1995
Speothalpius grayi Moore, 1995
Speozuphium Moore, 1995
Speozuphium poulteri Moore, 1995
Tachyta rexensis Moore, 2001
Tasmanorites aberrans Moore, 1972
Tasmanorites cordicollis Moore, 1972
Tasmanorites elegans Moore, 1972
Tasmanorites glaebarum Moore, 1972
Tasmanorites grossus Moore, 1972
Tasmanorites intermedius Moore, 1972
Tasmanorites laticollis Moore, 1983
Tasmanorites madidus Moore, 1972
Tasmanorites magnus Moore, 1972
Tasmanorites pullusminor Moore, 1972
Tasmanorites riparius Moore, 1972
Tasmanotrechus Moore, 1972
Tasmanotrechus cockerilli Moore, 1972
Tasmanotrechus compactus Moore, 1983
Tasmanotrechus concolor Moore, 1972
Tasmanotrechus elongatus Moore, 1994
Teraphis cavicola Moore, 1977
Thenarotes speluncarius Moore, 1967
Theprisa Moore, 1963
Trechiella queenslandica Moore, 1972
Trechimorphus apterus Moore, 1972
Trechimorphus brunneus Moore, 1972
Trechimorphus semipunctatus Moore, 1972
Trechimorphus westraliensis Moore, 1972
Trechistus Moore, 1972
Trechistus humicola Moore, 1972
Trechistus inconspicuus Moore, 1972
Trechistus stenoderus Moore, 1972
Trechistus sylvaticus Moore, 1972
Trechistus terricola Moore, 1972
Trechobembix baldiensis hesperia Moore, 1972
Trechobembix baldiensis queenslandica Moore, 1972
Trechodes crypticus Moore, 1972
Trechodes lustrans Moore, 1972
Trephisa Moore, 1963
Trephisa parallela Moore, 1963
Tropidotrechus vicinus Moore, 1972
Tropidotrechus bawbawensis Moore, 1972
Tropidotrechus microps Moore, 1972

NORFOLK ISLAND

Anomotarus (Anomotarus) discofoveatus Moore, 1985
Dicrochile idae Moore, 1985
Euthenarus bicolor Moore, 1985
Lacordairia insulicola Moore, 1985
Mecyclothorax monteithi Moore, 1985
Notoplatynus darlingtoni Moore, 1985
Pseudoceneus (*Poeciliridius*) *norfolkensis* Moore, 1985

LORD HOWE ISLAND

Lacordairia elongata Moore, 1992
Lacordairia taylori Moore, 1992
Mecyclothorax goweri Moore, 1992
Mecyclothorax howei Moore, 1992
Microferonia howei Moore, 1992
Scopodes ovalis Moore, 1992

NEW ZEALAND

Haplanister Moore, 1996
Haplanister crypticus Moore, 1996
Hygranillus Moore, 1980
Hygranillus kuscheli Moore, 1980
Pelodiaetodes Moore, 1980
Pelodiaetodes prominens Moore, 1980

NEW GUINEA

Gastragonum caecum Moore, 1978
Pseudozaena (*Trichozaena*) *cavicola* Moore, 1978
Speagonum Moore, 1978
Speagonum mirabile Moore, 1978
Trichozaena Moore, 1978

FIJI

Vitagonum Moore, 1998
Vitagonum apterum Moore, 1998

NEW CALEDONIA

Mecyclothorax kanak Moore & Liebherr, 2018
Mecyclothorax mouensis Moore & Liebherr, 2018

COLEOPTERA: PTINIDAE

ENGLAND

Ptinus clavipes Panzer form *mobilis* Moore, 1957

COLEOPTERA: LUCANIDAE

AUSTRALIA

Australognathus munchowae (Moore & Monteith, 2004)
Australognathus queenslandicus (Moore, 1978)
Cacostomus subvittata (Moore, 1994)

A MULTI-LOCUS PHYLOGENY, TAXONOMIC REVIEW AND DESCRIPTION OF NEW SPECIES OF AUSTRALIAN *NURUS* (SENSU STRICTO) MOTSCHULSKY, 1865 (COLEOPTERA: CARABIDAE: PTEROSTICHINI)

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Abstract

The genus *Nurus* Motschulsky, subgenus *Nurus* s. str., is revised, with three new species: *Nurus moorei* **sp. n.**, from southeastern Queensland and northern New South Wales, *N. popplei* **sp. n.** from near Torrington, New South Wales and *N. baehri* **sp. n.** from the Ebor region of New South Wales. *Nurus perater* (Sloane, 1923), **comb. n.**, originally described in *Trichosternus* Chaudoir, is redescribed. Redescriptions for the remaining four species in *Nurus* s. str., distribution maps and a key to species are given. Lectotypes are designated for *N. perater, N. latipennis* (Sloane) and *N. imperialis* (Sloane). Cladistic analysis of a combined matrix of partial sequences from three loci: 28S, COI and CAD, found support for the inclusion of *Trichosternus perater* Sloane in *Nurus* s. str. and the reciprocal monophyly of all populations represented for recognized species with the exception of *N. moorei*, which in some resulting trees was paraphyletic. Distributions of each of the three sister pairs found in the phylogenetic analysis (*N. moorei* + *N. imperialis*; *N. perator* + *N. atlas*; *N. baehri* + *N. popplei*) are distinctly allopatric. Several distantly related species overlap in their regional distributions but are separated at the local habitat level.

Introduction

One of the most prominent groups of carabid beetles in Australia is the Pterostichini. These beetles are frequently large, conspicuous and abundant in a wide variety of habitats. Given its diversity, the group attracted the attention of early authors studying the Australian fauna. In particular, the notable taxonomists M. Chaudoir, T. Tschitschérine, T.G. Sloane and P.J. Darlington all published scattered descriptive works and semi-synthetic treatments of the taxa included in their concept of the tribe. Until Barry Moore's treatment in 1965, there had not been a complete Australian faunal treatment at the genus level for the group. Several things set Moore's work above and beyond previous studies. Foremost, Moore provided a precise set of characters and states consistently for every genus, which allowed for clear identification and comparison. These remain fundamental characters for any morphological study of pterostichines. He also established informal series, *i.e.* groups of genera, based on these characteristics and his explicit interpretation of them. These series continue to be useful and largely supported by more expansive analyses (Will 2015, KWW unpublished). Whereas Darlington (1961b) had treated *Castelnaudia* Tschitschérine as a synonym of *Trichosternus* Chaudoir, Moore recognised they had distinct male genitalia and treated them as separate genera. Moore also insightfully pointed out the problematic placement of *C. obscuripennis* (Macleay) and unresolved issues with *Nurus* s. lat. and its relationship with the broader

Trichosternus series. Moore also published a comprehensive catalogue of the Australian Pterostichini (Moore *et al*. 1987).

Based on Moore's (1965) treatment, the genera of the *Trichosternus* series can be distinguished from other Australian and New Zealand pterostichines by the following combination of characteristics: 1, mentum long and deeply emarginate; 2, ostium of the median lobe of the aedeagus deflected to the right; 3, antennae not geniculate; 4, abdominal ventrites not transversely sulcate. In addition to these character states, the included taxa have: 1, the stipes bearing two or more setae; 2, three or more umbilicate punctures basal of the relatively larger puncture at the junction of striae 8 and 9 near the elytral humeral margin; 3, female reproductive tract with spermathecal gland duct diverticulum; 4, pygidial gland reservoirs lacking dorsal lobes.

This combination of character states is found in all genera in the *Trichosternus* series except *Acanthofernia* Moore, which was shown to be a taxon derived within *Notonomus* Chaudoir (Will 2015). As noted in various contexts by Moore (1965), Darlington (1961a, 1961b), Sloane (1895) and Tschitschérine (1902), the three most species-rich genera in the series, *Trichosternus*, *Castelnaudia* and *Nurus* s. lat., are closely related and problematic. As presently constituted (Lorenz 2005, 2018), they do not have any clear characters to define them as reciprocally separate groups. Resolution of that problem is beyond the scope of this contribution but an ongoing, combined multi-gene and morphological study across the group supports clades that correspond to those genera, places problem taxa and, most significant to the present work, supports the monophyly of *Nurus* s. str. including *Trichosternus perater* Sloane.

Several subgeneric groups have been recognised within *Nurus* s. lat. and Darlington (1961a) discussed problems with the application of these. His key distinguishes subgenus *Nurus* s. str. as a southern group of species that lack setae on the mesosternum but he did not deal with this group in that paper and they are revised in the present work. *Nurus s. str*. includes eight species distributed from Mt Tamborine, Qld south to the Ebor district, NSW and from the Pacific coast west as far as Torrington, NSW.

Although large and impressive carabids, with some species having striking metallic coloration, specimens of *Nurus* s. lat. were rare in collections until the 1970s, when it was discovered (GBM pers. obs.) that all species live in deep burrows with a distinctive, specialised entrance 'stage' where they ambush prey (Charley and Andren 2018). Once this was known they could be readily searched for, dug up and many specimens accumulated for study. GBM (pers. obs.) has also noted their brood care behaviour, in which eggs are deposited in soil capsules similar to those described for the pterostichine genus *Percus* Bonelli in Europe (Kavanaugh 1998).

Some species of *Nurus* s. str. have very restricted distributions and their rarity due to habitat loss by clearing, in the Lismore district of New South Wales, led to them being used to mount a case to list rainforest remnants at Victoria Park, with *Nurus atlas* (Laporte) and, at Rotary Park, with *Nurus brevis* Motschulsky, on the Australian National Estate Register (Greenslade 1994). Both species were later listed in 2001 as 'endangered species' protected by legislation in New South Wales (NSW National Parks and Wildlife Service 2002). A detailed survey of the current status of *Nurus atlas* was carried out in 2017-18 (Charley and Andren 2018).

Materials and methods

Morphological methods. Dissection methods for male and female genitalia and defensive glands and descriptive terms follow Liebherr and Will (1998) and Will (2002). Images were taken using a Microptics XLT digital imagining system and subsequently edited to enhance clarity using standard image editing software.

Measurements. Overall length is the length from the base of mandibles to apex of elytra. The ocular ratio is the width between the eyes at the level of the anterior supraorbital setae divided by the greatest width of the eyes as viewed from above. For new species, measurement of holotype is given first with range of paratypes in parentheses.

Taxon sampling. This includes four putative outgroup taxa: *Castelnaudia marginifera* (Chaudoir), *C. septemcostata* (Chaudoir), *Trichosternus renardi* (Chaudoir) and *T. vigorsi* (Gory). The last of each pair are the type-species of their respective genera. All species of *Nurus* s. str. are included with multiple individuals from across their ranges. A total of 47 OTUs are included in the analysis. Taxon names and authors follow Lorenz (2018).

Material examined. Specimens included in the current study include both ethanol preserved and pinned adults. A total of 789 specimens were examined from the following collections: AM – Australian Museum, Sydney; ANIC – Australian National Insect Collection, Canberra; CBM – M. Baehr collection in Zoolgische Staatssammlung, München, Germany; EMEC – Essig Museum of Entomology, Berkeley, California; MCG – Museo Civico di Storia Naturale, Genoa; MV – Museum of Victoria, Melbourne; QDAF – Queensland Department of Agriculture and Fisheries Collection, Brisbane; QM – Queensland Museum, Brisbane; Additional specimens were examined by KWW in MCZ – Museum of Comparative Zoology, Harvard University, in 2017 but locality data were not recorded and specimens are not enumerated here.

All specimens are listed in abbreviated form in the material examined lists. Since most *Nurus* species cannot be sexed on external characters, sex is not recorded. Same localities are always listed in sequence with 's. l.' (same

locality) used for the name after first mention. Museum locations refer to specimens listed prior to the museum acronym. Repeated collector names are shown by initials as follows: AC, A. Calder; AM, A. Musgrave; AML, A. M. Lea; BC, B. Cantrell; BPM, B. P. Moore; CG, C. Geissman; CJW, C. J. Wild; CMD, C. M. Deuquet; CO, C. Oke; DAD, D. A. Doolan; DC, D. Charley; DKM, D.K. McAlpine; DP, D. Potter; FF, F. T. Fricke; FT, F. Turco; DJC, D. J. Cook; DKY, D. K. Yeates; ES, E. Sutton; GC, G. Czechura; GIT, G. I. Thompson; GBM, G. B. Monteith; GC, G. Cassis; HAL, H. A. Longman; HH, H. Hacker; HJ, H. Janetzki; HWB, H.W. Brown; HT, H. Tryon; IDN, I. D. Naumann; JB, J. Balderson; JD, J. Doyen; JS, J. Stanisic; KWW, K. Will; MG, M. Gray; NG, N. Gough; PB, P. Bouchard; PZ, P. Zborowski; RB, R. Blackwood; RI, R. Illidge; RIS, R. I. Storey; RJT, R. J. Tillyard; RM, R. Menendez; RO, R. Overland; RPJ, R. P. Johnson: RR, R. J. Raven; SRB, S.R. Brock; SRM, S. R. Monteith; TGS, T. G. Sloane; TW, T. A. Weir.

Other abbreviations: m, metres; ml., miles; km, kilometres; for., forest; NP, National Park; R, River; SF, State Forest; EMEC numbers are for specimens sequenced in the Will lab, vouchered in the Essig Museum, Berkeley University, California and/or data captured in the EssigDB but housed elsewhere.

DNA sequencing and analysis methods. Partial sequences for four loci were used: 1133bp aligned length of 28s rDNA (28S); 706pb + 828bp for the two primer pairs of cytochrome oxidase I (COI); and 905bp carbamoyl phosphate synthetase domain of the rudimentary gene (CAD). Primers and PCR protocols follow Will and Gill (2008), Gunter *et al.* (2013) and Will (2015), with the additional use of alternative CAD primers 5'.AACGCAAACG ACCACACAAA.3' and 5'.TGAGCTAGTGCTTGAAGAGCC.3' for some sequences. The matrix is complete for these four loci except for two *N. latipennis* (Sloane 1903) sequences: 28S is missing for the Whian Whian specimen and COI Folmer region (Folmer *et al.* 1994), *i.e.*, the 5' half of COI, is missing for the southern Tweed Range specimen. Sequences have been deposited in GenBank with the following accession numbers: 28S: MK090893–MK090938, CAD: MK090939–MK090985, COI: MK090986–MK091078.

Alignment of the protein-coding sequences was straightforward, without gaps. Multiple sequence alignment of 28S was performed by MAFFT ver. 7 (Katoh and Kuma 2002) using default parameter values within Mesquite (Maddison and Maddison 2018b). The concatenated matrix of the four loci was submitted to TNT (Willi Hennig Society edition, ver 1.5 (Goloboff *et al.* 2008) using Zephyr ver. 2.11 (Maddison and Maddison 2018a) and the default search settings were used in Mesquite for both parsimony tree and jackknife resampling searches. For jackknife analysis, 5000 replications were done.

Phylogenetic analysis results

TNT returned 20 equally parsimonious trees 1075 steps long, with CI = 0.70 and RI = 0.88. The strict consensus of those 20 trees is identical to the jackknife tree (Fig. 39), with the exceptions of some additional but very poorly supported resolution seen within the *N. atlas* clade. The jackknife support values are high for all clades from the root of the ingroup to the nodes subtending all recognized species except for *N. moorei*. *Nurus moorei* specimens from the disparate samples of Numinbah Arch and Hayter's Hill form a clade that was placed sister to the remaining *N. moorei* OTUs or sister to the *N. imperialis* clade in exactly half of the trees, each. *Nurus perater* was placed unambiguously within the *Nurus* s. str. clade and showed no affinity with the two *Trichosternus* outgroup taxa.

Taxonomic treatment

Nurus (sensu stricto) Motschulsky, 1865

Characteristics, modified from Moore (1965): Mentum deeply emarginate, sides of sinus subparallel; median tooth entire, emarginate or bifid; paraglossae glabrous; antennae filiform, with three basal segments glabrous; postocular orbits inconspicuous. Pronotum cordiform or subquadrate, the margins bisetose; prosternum setose, mesosternum glabrous. Elytra fused; striae variable, intervals more or less convex or nearly flat; parascutellary striae present or absent; discal pores small, confined to the third intervals when present; marginal pores small; plica not externally visible, inner ridge present but not prominent; hind wings vestigial, strap-like. Legs relatively slender; metacoxae prominent, posterior face vertically oriented; anterior tarsi of male usually unmodified, two or three basal segments squamose beneath in *N. atlas* and *N. perater*, respectively; tarsomere 5 of all legs ventrally setose. Aedeagus (Figs 15-38) with orifice deflected to the right; parameres dissimilar, the left conchoid, the right longer, falcate.

Type species. *Nurus brevis* Motschulsky, 1865.

Included species (Figs 1-8). *Nurus atlas* (Laporte), *N. perater* (Sloane), **comb. n.**, *N. brevis* Motschulsky, *N. latipennis* (Sloane), *N. popplei* **sp. n.**, *N. baehri* **sp. n.**, *N. imperialis* (Sloane) and *N. moorei* **sp. n.**

Nurus atlas (Laporte, 1867)

(Figs 1, 11, 14-17, 40)

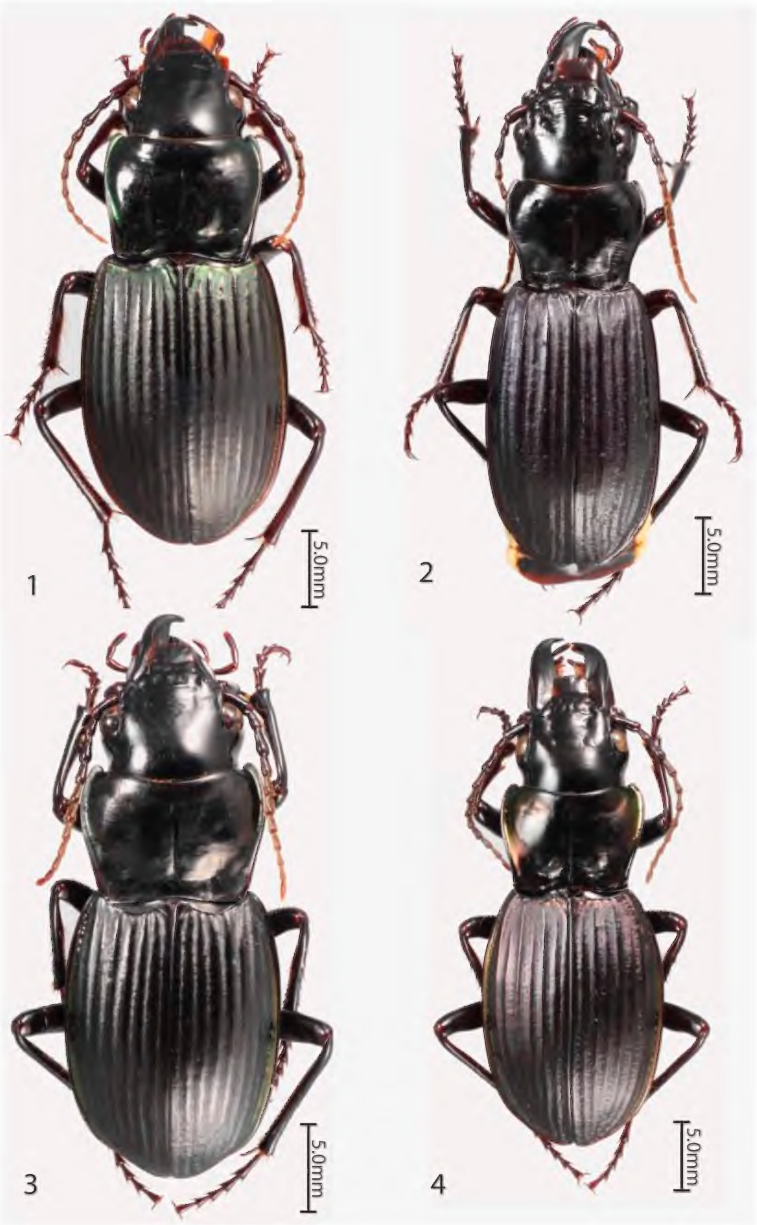
Feronia atlas Laporte, 1867.

Nurus atlas (Laporte): Tschitschérine (1902).

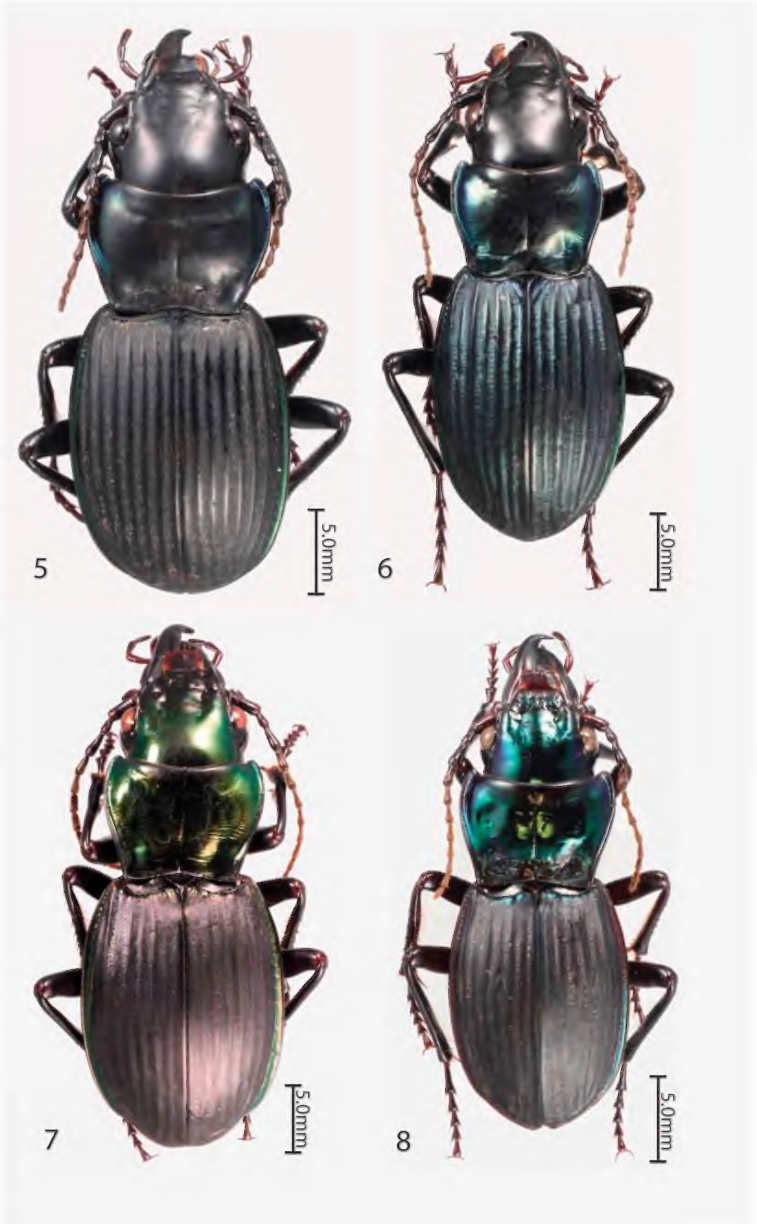
Feronia obesa Laporte, 1867.

Homalosoma crassiforme Sloane, 1900.

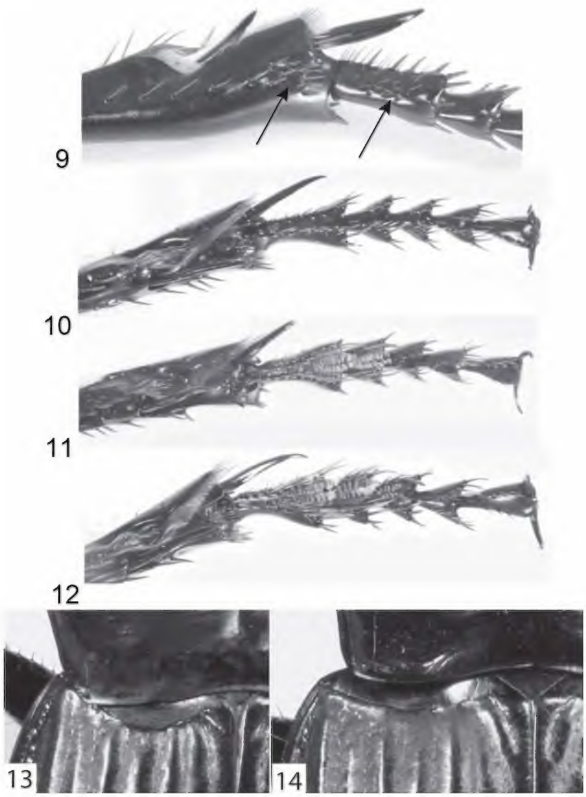
Type material. *Lectotypes* for *Feronia atlas* and *Feronia obesa* designated by Straneo (1936) in MCG; not examined. *Syntype* of *Homalosoma crassiforme* Sloane: 1, 'Cairns, Qld', in MV; examined.



Figs 1-4. Dorsal views of *Nurus* spp: (1) *N. atlas*; (2) *N. perater*; (3) *N. brevis*; (4) *N. latipennis*.



Figs 5-8. Dorsal views of *Nurus* spp: (5) *N. popplei* **sp. n.**; (6) *N. baehri* **sp. n.**; (7) *N. imperialis*; (8) *N. moorei* **sp. n**.



Figs 9-14. *Nurus* spp, characters of protibia, protarsus and elytral base: (9) ♂ *Nurus moorei* **sp. n.**, medial view of apical portion of right protibia and protarsomeres. Arrows indicate region of setae on protibia and protarsomere 1; (10-12) ventral view of apical portion of left protibia and protarsomeres of male: (10) ♂ *N. moorei,* lacking squamous setae on all tarsomeres; (11) ♂ *N. atlas,* with squamous setae on tarsomeres 1-2; (12) ♂ *N. perater*, with squamous setae on tarsomeres 1-3; (13-14) basal margin of left elytron: (13) *N. brevis*; (14) *N. atlas*.

Other material examined. (96): NEW SOUTH WALES: 5, Victoria Park, 7.5 km SSW Alstonville, 9.xii.1973, GBM; 5, s. l., 23.iii-2.viii.1975, GBM & SRM; 1, s. l., 16.xi.1974, GBM; 1, s. l., 2.viii-15.xi.1975, GBM & SRM; 8, s. l., 26.xii.1974-23.iii.1975, GBM & SRM; 2, s. l., 29.i.2008, GBM & FT (one is EMEC346319); 1, s. l., 12.vii.2016, GBM (EMEC346320) (QM); 1, Victoria Park, 29 Jan 2008, GBM & FT (EMEC 346318) (EMEC); 2, s. l., 9.xii.1973 (ANIC); 1, s. l., 9.xii.1973 (QM); 1, s. l., 19-20.i.1974, RIS (QDAF); 6, Lumley Park, Alstonville, 23.iii.1975, GBM (QM); 1, Davis Scrub, 4.5 km SW of Alstonville, 3.ii.2009, GBM (AM); 2, s. l., 29.i.2008, GBM & FT (2 are EMEC346322 & EMEC346323) (QM); 2, same data (CBM); 1, s. l., 29 Jan 2008, GBM & FT (EMEC346321); 1, 2.6 km N of Wardell, 2013, L. Popple (EMEC346324) (EMEC); 8, Molly's Grass, nr. Tregeagle, 10 km SE

of Lismore, 10.i.-21.ii.1982, DKY; 1, s. l., 4.iv.2018, DC (EMEC1411129); 1, Brockley North Scrub, 10.5 km E of Lismore, 28.iv.1018, DC, (EMEC1411127); 1, Whites Lane Scrub, 2.5 km SW of Wollongbar, 3.iv.2018, DC (EMEC1411128); 1, Willowbank Scrub, 4.9 km N of Alstonville, 27.iv.2018, GBM (EMEC1411126); 1, Wollongbar Research Stn, 27.iii.2018, GBM (EMEC1411125); 2, Lismore, CD (QM); 1, Lismore, CMD; 1, Richmond R. K14453; 1, s. l., ES; 18, s. l., 14.xii.1976, FF (AM); 1, s. l., CD (QM); 1, s. l.; 4, Tweed R. (MV); 2, s. l., HWB; 2, Alstonville, 13.xii.1976, FF (AM); 1, Alstonville, xii.1976, FF; 1 ♂, New Holland/Ehlers; 1, Wollongbar, 1897 (ANIC); 1, Wardell (MV); 1, no data (QM); 5, no data (ANIC).

Type localities. For *F. atlas* and *F. obesa*: Clarence River, NSW; for *H. crassiforme*: 'Cairns' (spurious). The name 'Clarence River' was used as a broad district name that included the Clarence River watershed and adjacent areas during the early days of settlement in the mid-1800s when the types were collected. The species has been very well surveyed (Charley and Andren 2018) and does not occur in the Clarence River watershed but in a very restricted part of the Richmond River drainage a little further north.

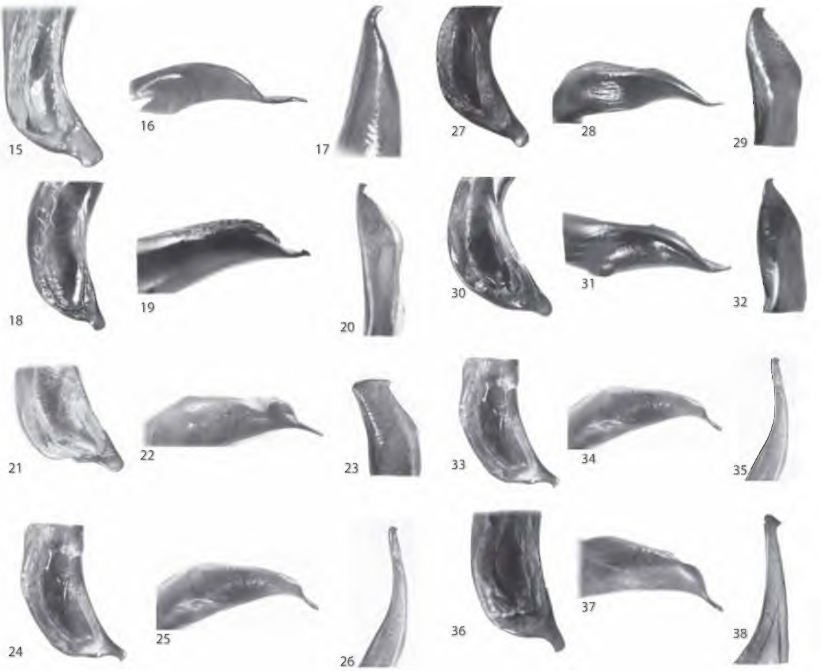
Diagnosis. Males of *N. atlas* can be distinguished from all other *Nurus* species by the presence of pads of squamose setae ventrally on protarsomeres 1 and 2 and not on 3 (Fig. 11). *Nurus atlas* is relatively robust and broad-bodied with a nearly quadrate pronotum (Fig. 1). Typically, the pronotum is metallic green or bronze, although the colour is sometimes subtle or nearly absent.

Redescription. Size. Overall length 28.5-30.5 mm; greatest width of elytra 10.8-12.9 mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae dark piceous or black. Pronotum rarely all black, typically broadly across the base and laterally metallic green. Elytral disc black or with slight metallic green or bronze reflectance and lateral margins of elytra metallic bronze or copper, rarely metallic green. *Lustre*. Dorsally head, pronotum and elytral margins very glossy; elytral disc duller in striae and intervals dorsally contrastingly glossier; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines not visible at 50x magnification. Clypeal-ocular sulci absent. Ocular ratio 0.73-0.76; eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight or convex, medial four setae separated from each other about half to three quarters width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth emarginated; constantly with one pair of setae positioned at base of median tooth and a second pair of smaller setae laterad of medial pair. Submentum with two lateral pairs of setae. Gula narrow, width at middle about as wide as width of mentum tooth. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum quadrate, sides subsinuate and then straight or very slightly convergent onto base. Marginal bead thick, continuous from apex to base,

slightly wider near base; basal margin not bordered, straight or slightly emarginated medially; anterior angles prominently produced; hind angles about right-angled or slightly obtuse and rounded and not denticulate; base depressed, basal impressions very broad, shallow and not clearly delimited or deeply impressed; deep to shallow, transverse linear sulci distant from basal margin. Anterior marginal seta set mesad lateral channel. Seta near hind angle set in lateral bead. Microsculpture of disc not visible at 50x magnification except near base where microlines form very irregular transverse mesh. Prosternal process medial impression present near apex deep, process apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 present, distinctly impressed. Elytral parascutellar setae present or absent, basal margin sharply bordered. Striae marked with dense, shallow, elongate punctulae. Elytra with nine intervals, 1-7 convex. Elytral microsculpture laterally on intervals 1-8 and in striae dense, small, granular, composed of irregular sculpticells giving a dull sheen, contrasting with convex area of intervals 1-7 that has a glossy lustre due to shallow or absent microsculpture. Interval 3 with zero to three setae. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 30-38 umbilicate setae, somewhat irregularly spaced but more closely set anteriorly and posteriorly. Stria 7 variable apically, apparent or anastomosed with stria 8. When stria 7 evident, two umbilicate setae present. Elytral humeri with distinct, low tooth oriented dorsally or posteriorly. Elytra lacking externally visible plica, apiocolaterally internal ridge scarcely apparent. Vestigial flight wing present as a thin strap about 1/6 elytral length. Male protarsi slightly asymmetrically expanded and with squamose setae ventrally on 1 and 2; female protarsi symmetrical and ventrally glabrous. Protibia without anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 typically with four setae in males and six setae in females but number varies, especially in females.

Male genitalia. Aedeagus (Figs 15-17) right paramere long, broad at base and tapering apically, narrowed and curved, left paramere broadly rounded at apex, conchiferous; tip of median lobe rounded. Dorsal ostium wide and rotated to right.

Distribution (Fig. 40). The entire distribution of *Nurus atlas* lies within a 10 km radius of the town of Alstonville in northern New South Wales. All occurrences are within small remnants of an extensive block of rainforest that once covered the fertile volcanic soils of this area. A detailed survey of its distribution is given by Charley and Andren (2018). Its range is separated by the deep valley of the Wilson River from that of *N. perater*, *N. latipennis* and *N. moorei* in the Nightcap Range, only 25 km north and north-west.



Figs 15-38. Aedeagus, dorsal view of apical portions of median lobe, left lateral view of apical portion of median lobe and apical portion of left paramere, respectively, for *Nurus* spp: (15-17) *N. atlas*; (18-20) *N. perater*; (21-23) *N. brevis*; (24-26) *N. latipennis*; (27-29) *N. popplei* sp. n.; (30-32) *N. baehri* sp. n.; (33-35) *N. imperialis*; (36-38) *N. moorei* sp. n.

Nurus perater (Sloane, 1923), comb. n.

(Figs 2, 12, 18-20, 40)

Trichosternus perater Sloane, 1923.

Type material examined. *Lectotype* ♂, here designated, genitalia dissected and glued on card- // 'Tweed R 10.04 HJC' [H.J. Carter] // [handwritten red ink] // 'Trichosternus perater Sl. Cotype.' // [mixed print and type on pink paper] // 'T. perater Sl. HOLOTYPE PJD' // 'ANIC Database No. 25 014984' //. Darlington placed a holotype label on the specimen but did not publish that action (ANIC). *Paralectotypes*: ♀ // 'Tweed R 10.04; // [handwritten red ink] // 'Trichosternus perater Sl. Cotype' // [print] // 'ANIC Database No. 25 014985' //. ♀ [handwritten red and black ink] // 'Trichosternus perater Sl. Cotype ♀' // [print on blue paper] // 'PARATYPE' // 'ANIC Database No. 25 014986' // (ANIC). Two specimens 'T11905 Tweed River' and 'T11906 Tweed River' (MV).

Other material examined. (148): QUEENSLAND: 3, Mt Cougal, 400 m, 18.i-27.iv.1987, GBM & DJC; 7, s. l., 2.xi.1986-19.i.1987, GBM & DJC; 2, s. l., 14.vi-19.xi.1987, GBM & DJC; 7, Mt Cougal, 500 m, 19.xi.1987-17.iii.1988, GBM & DJC;

3, s. l., 19.xi.1987, GBM & DJC; 1, Mt Gannon summit, 700 m, 1.vii-2.xi.1986, GBM & DJC (QM); 1, s. l., 29.xi.2010, KWW; 1, Numinbah Arch, 300 m, 2.xii.2017, GBM (EMEC); 8, s. l., 25.iv.1974, GBM; 2, s. l., 1.i-29.ii.1992, DJC, pitfall trap; 3, s. l., 14.xii.1974-22.iii.1975, GBM & SRM; 3, s. l., 22.iii-25.v.1975, GBM & SRM; 2, s. l., 25.v-13.x.1975, GBM & SRM; 8, s. l., 26.x-14.xii.1974, GBM & SRM; 1, Mt Gannon, 400 m, 2.xi.1986-18.i.1987, GBM & DJC; 7, s. l., 18.i.-5.iv.1987, GBM & DJC; 1, Springbrook Repeater Stn, 1010 m, 9.i-19.ii.1995, GBM; 1, s. l., 30.viii-31.x.1997, GBM; 1, s. l., 31.x-31.xii.1997, GBM; 1, Goomalahra, Springbrook, 9-10.ii.2016, GBM; 2, Lyrebird Ridge Rd, Springbrook, 770 m,19-29.ii.2016, GBM; 1, Lyrebird Ridge Rd, Springbrook, 805 m, 19-20.x.2016, Asquith; 1, Ankida, across creek, Springbrook, 22.x.2015, GBM; 1, Upper Tallebudgera Valley, 560 m, 6.iii-28.iv.1992, DJC; 1, s. l.,18.xi.-28.xii.1991, DJC; 1, s. l, 28.xii.1991-6.iii.1992, DJC; 1, s. l., 29.xii.1984, GBM & DJC; 1, s. l., 11.iii.1989, GBM; 1, s. l., 11.iii.1984, DJC; 1, s. l., 1.iii-31.vii.1998, DJC; 8, s. l., 8.i.-17.iii.1985, GBM, DJC & GIT; 8, Upper Tallebudgera Valley, 500 m, 8.i.-17.iii.1985, GBM, DJC & GIT; 1, Upper Tallebudgera Valley, 400 m, 15.iv.1995, GBM; 8, Upper Tallebudgera Valley, 350 m, 19.xi.2007, GBM, DJC & FT (QM); 2, same data (CBM)3, Upper Tallebudgera Valley, 330 m, 2.i-17.ii.1995, DJC; 2, Upper Tallebudgera Valley, 300 m, 8.i.-17.iii.1985, GBM, DJC & GIT; 1, Tallebudgera Valley, falls area, 150 m, 11.xi.1997-28.i.1998, DJC; 1, Tomewin Range, 500 m, 17.x.1988, GBM; 5, s.l, 16.v.1989, GBM; 1, s. l, 19.x.1989, GBM (QM); 4, Springbrook, 1930, RB; 1, Mt Cougal NP; 1, Tomewin Range (AM). NEW SOUTH WALES: 1, Couchy Creek, 4 km S of Numinbah gate, 200 m, 25.iv.1974, GBM; 2, Mt Nardi, 760 m, 26.xii.1974-23.iii.1975, GBM & SRM; 1, S. l., 11.iii.1987, JS & DP; 1, Mt Warning, 400 m, 30.viii.1972, GBM; 3, s. l., 7.iii-13.vi.1976, GBM & SRM; 1, s. l., 13.vi.-7.xi.1976, GBM & SRM; 1, s. l., 16.xi.1975-7.iii.1976, GBM & SRM; 1, s. l.,19.xi.2007, GBM & SRM; 1, s. l., 10.vii.1961, B. Timms (QM); 1, s. l., 17.ii.1989, Hines, Pugh, Weber, Smith; 4, Billinudgel, 1930; 1, Huonbrook, 30.i.1961, DKM; 1, Nightcap Range, 17.ii.1989, Hines, Pugh, Smith, Weber; 1, NSW, F. Taylor (AM); 2, Mt Matheson, Nightcap Range, 800 m, 23.iv.2002, GBM; 1, Byrrill Ck, Mebbin NP, 19.xi.2007, GBM & RM; 1, Byron Bay, ix.1909, CD (QM); 2, Upper Wilson's Creek, 4.xii.2017, GBM (EMEC).

Type locality. The collector of the type material, H.J. Carter, used the label 'Tweed R.' for specimens collected while based at Murwillumbah, on the Tweed River, during a train and bicycle collecting trip in 1904 (Carter 1933). In a footnote, Carter (1933: 82) listed *Trichosternus renardi* (Chaudoir) as among his collections from 'Tweed R.'. That species resembles *N. perater* superficially but occurs only further north in Queensland and is what he would have assumed his specimens to be at that time. *Nurus perator* does not occur close to the lower Tweed River, which floods regularly, but Carter described riding north from Murwillumbah to the Queensland border gate for collecting. That point is the crest of the Tomewin Range (28.903ºS, 153.366ºE) where *N. perater* is common. It is within the Tweed River watershed and is almost certainly where he collected the type series.

Diagnosis. Male *N. perater* are distinguished from all other *Nurus* species by the presence of pads of squamose setae ventrally on protarsomeres 1 to 3 (Fig. 12). *Nurus perater* is a very large, parallel-sided, black species without

coloured reflections (Fig. 2). It is rather similar to *Trichosternus renardi* (Chaudoir) but, like all *Nurus s.str.* species, *N. perater* lacks the field of long setae on the mesosternum present in *T. renardi*. In *N. perater* elytral interval 7 and stria 7 end well before the apex, in contrast with *T. renardi,* where interval 7 is convex and continuous apicad of intervals 3-6 and stria 7 is deeply sulcate and has two setae apically.

Redescription. *Size*. Overall length 31.8-35.5 mm; greatest width of elytra 12.1-14.1 mm. *Colour*. Dorsal and ventral surfaces black; legs, mouthparts and antennae black or dark piceous. *Lustre*. Dorsally head, pronotum and elytral margins glossy; elytral disc duller but intervals dorsally contrastingly glossier; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines visible at 50x magnification, microlines forming irregular mesh, vertex smooth. Clypeal-ocular sulci represented by very broad, very shallow, poorly defined impressions. Ocular ratio 0.69-0.73; eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight or slightly convex and raised medially, medial four setae separated from each other about half width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth entire or slightly emarginated, with one pair of setae positioned at base of median tooth. Submentum with two lateral pairs of setae. Gula narrow, width at middle about as wide as mentum tooth at base. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 slightly compressed at base. *Thorax*. Pronotum transverse, sides sinuate and then straight onto base. Marginal bead thick, continuous from apex to short of base where it narrows and is not medially delimited; basal margin not bordered, nearly straight medially; anterior angles prominently produced; hind angles right-angled; base depressed, impressions well impressed, linear, broad and not clearly delimited; deep transverse linear sulci basad impressions, rather distant from basal margin. Anterior marginal seta set in edge of lateral channel. Basal seta just anterad hind angle. Microsculpture of disc hardly visible at 50x magnification, where evident microlines form irregular, transverse mesh producing a slight spectral iridescence. Prosternal process medially with deep impression present near apex, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete but shallowly impressed. Parascutellar striae and angular base of stria 1 present, distinctly impressed. Elytral parascutellar setae present or absent, basal margin sharply bordered. Striae, where marked, with dense, shallow punctulae. Elytra with nine intervals; intervals 1, 3, 5 and 7 clearly raised and carinate or subcarinate, 2, 4 and 6 flat or slightly convex. Elytral microsculpture laterally on intervals 1-8 and in striae dense, small, granular, composed of irregular sculpticells giving a dull sheen, dorsal area of interval's convexity somewhat glossy lustre due to shallow or absent microsculpture. Interval 3 with three to four setae. Interval 9 and marginal

channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 42-43 umbilicate setae, somewhat regularly spaced along length. Stria 7 not evident apically. Elytral humeri with distinct, sharp, dorsally oriented tooth. Elytra lacking externally visible plica, apiocolaterally internal ridge scarcely apparent. Vestigial flight wing present as a thin strap about 1/6 elytral length. Male protarsi slightly asymmetrically expanded and with squamose setae ventrally on 1-3; female protarsi symmetrical and ventrally glabrous. Protibia without additional anterioapical field of setae between antennal cleaner and apical margin near longitudinal row of setae above antennal cleaner groove (*contra* Fig. 9). *Abdomen*. Abdominal ventrites smooth, 2-5 with a pair of paramedial setae. Apical margin of ventrite 6 with two setae in male and four in female.

Male genitalia. Aedeagus (Figs 18-20) right paramere long, broad, short narrowed section curved at apex with sharp hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe rounded. Dorsal ostium wide and rotated to right.

Distribution (Fig. 40). *Nurus perater* occurs at high and low elevations in rainforests on the eastern half of the Tweed Shield Volcano straddling the border between Queensland and New South Wales. These include occurrences on Springbrook Plateau and its peripheral ranges and valleys, Mt Warning and the Nightcap Range. It occurs in Mebbin NP at the base of the Tweed Range but not elsewhere in the large Tweed-Lamington massif. An old record from Billinudgel near the coast east of the Nightcap Range has not been confirmed by recent collecting. *N. perater* co-occurs with *N. moorei* at low elevation sites east and west of Springbrook.

Nurus brevis Motschulsky, 1865

(Figs 3, 13, 21-23, 42)

Nurus brevis Motschulsky, 1865.

Feronia solandersii Laporte, 1867.

Type material: Possible syntypes of *N. brevis* in Zoological Museum of Moscow University; not studied. Lectotype of *F. solandersii* in MCG designated by Straneo (1936); not studied.

Other material examined. (58): NEW SOUTH WALES: 2, Blue Gum Hut, Richmond Range, 12.x.1977, GBM; 6, s. l., 7.ii.-6.v.1978, GBM; 8, s. l., 12.x.1977-7.ii.1978, GBM; 1, s. l., 27.v-2.x.1978, GBM; 1, s. l., 12.x.1977, GBM; 1, s. l., 2.ii.2009, GBM (EMEC346336); 1, s. l., 17.i.1992, JS & J. Chaseling (QM); 1, s. l., 1977-78, GBM; 1, Cambridge Plateau, 300-600 m, 17.xii.1988, Smith, Hines, Pugh,Webber (AM); 2, s. l., 19-21.x.1990, M. DeBaar; 2, s. l., 29.xi.2016, GBM (EMEC346334, EMEC346335) (QM); 2, same data (EMEC346332 & EMEC346333) (EMEC); 3, Rotary Park, Lismore, 26.xi.1972, GBM; 1, s. l., 9.xii.1973, GBM; 1, s. l., 1974, GBM & SRM; 1, s. l., 26.xii.1974-23.iii.1975, GBM & SRM; 1, s. l.,12.vii.2016 (EMEC346341) (QM); 2, s. l., NSW,26.xi.1972, GBM (ANIC); 1, s. l., 8.v.1973, RIS (DAF); 1, Lismore, 3.ii.2009, GBM & FT; 3, Wilson Park, Lismore, 29.i.2008, GBM

& FT (QM); 1, same data (AM); 1, same data (CBM); 1, s. l., 12.vii.2016, GBM (EMEC346340) (QM); 2, s. l., 28.i.2008, GBM & FT (EMEC346338 & EMEC346339) (EMEC); 2, Cherry Tree SF, via Mallanganee, 12.x.1977, GBM; 1, s. l., 2.x.1978-22.ii.1979, GBM; 1, Bulmers Rd, Mallanganee SF, 1.xii.2016, GBM (EMEC 346337) (QM); 1, Coll. French; 6, V. de Poll / *Trichosternus brevis* Id by Sloane (ANIC).

Type localities. For *N. brevis*: 'Nouvelle Hollande'. For *F. solandersii*: 'Clarence River'. See discussion under *Nurus atlas* for comment on the interpretation of 'Clarence River' as a collection locality in the mid-1880s. The known range of *N. brevis* lies mostly within the Richmond River drainage at Lismore but its western population along the Richmond Range is on the watershed between the Richmond and Clarence Rivers.

Diagnosis. Nurus brevis has a relatively broad form, similar to *N. popplei*. However, *N. brevis* has the pronotal basal margin more distinctly concave and the basal margin of elytra clearly sinuate, whereas *N. popplei* has a shallowly emarginate pronotal base and nearly straight basal elytral margin (Figs 13-14).

Redescription. Size. Overall length 23.5-28.2 mm; greatest width of elytra 9.5-11.6 mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae black or dark piceous. Pronotum all black or subtle metallic green at lateral and basal margins. Elytral disc black, lateral margins of elytra metallic green or mixed with a little copper. *Lustre*. Dorsally head, pronotum and elytral margins glossy; elytral disc slightly duller than forebody but also glossy; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines visible at 50x magnification, microlines forming irregular, slightly transverse mesh, vertex smooth. Clypeal-ocular sulci absent or represented by broad, very shallow, poorly defined impressions. Ocular ratio 0.70-0.73; eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight, medial four setae separated from each other about three-quarters width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth emarginate or entire; constantly with one pair of setae positioned at base of median tooth, occasionally with two pairs of setae laterad of medial pair. Submentum with two lateral pairs of setae. Gula narrow, width at middle slightly wider than mentum tooth at base. Antennae moderately long, antennomere 11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse, sides subsinuate or not sinuate and convergent to base. Marginal bead thick, narrowed apically, ending at level of basal impression or scarcely marked medially and ending near hind angles; basal margin not bordered, deeply and broadly emarginated medially; anterior angles very prominently produced; hind angles obtuse or nearly right-angled, not denticulate; base broadly depressed, basal impressions not apparent or very broad and not

clearly delimited. Anterior marginal seta set mediad and touching lateral channel. Posterior seta set in hind angle. Microsculpture of disc visible at 50x magnification, microlines form very irregular, somewhat transverse mesh; often with a slight spectral iridescence. Prosternal process medial impression present near apex, varying from very shallow to shallow, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, very broadly and shallowly impressed. Parascutellar striae very short or absent and angular base of stria 1 present, distinctly impressed. Elytral parascutellar setae absent, basal margin sharply bordered and deeply concave. Striae typically smooth or occasionally marked with dense, shallow punctulae. Elytra with nine scarcely convex intervals. Elytral microsculpture on intervals 1-8 and in striae dense, small, granular, composed of irregular sculpticells giving a dull sheen, dorsal area of interval's convexity slightly glossier due to shallow microsculpture. Interval 3 with 0-2 setae. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 28-36 umbilicate setae, somewhat irregularly spaced but more closely set anteriorly. Stria 7 not evident near apex. Elytral humeri with distinct, sharp or somewhat rounded tooth. Elytra lacking externally visible plica, apiocolaterally internal ridge low small but apparent. Vestigial flight wing present as a thin strap about 1/6 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia without anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 with four setae in males, four to six setae in females. Female also with one or two pairs of subapical setae medially on ventrite 6.

Male genitalia. Aedeagus (Figs 21-23) right paramere moderately long, very broad, bluntly rounded at apex with sharp hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe elongate and rounded. Dorsal ostium wide and rotated to right.

Distribution (Fig. 42). *Nurus brevis* now occurs in two disjunct areas about 50 km apart. The easternmost occurrence is in dry lowland rainforests along the Wilson River in and adjacent to the city of Lismore. The other population is in wetter rainforests of the Cambridge Plateau at the southern end of the Richmond Range as well as the dry rainforests in foothills a little further south near Mallanganee. These two populations might have been contiguous before complete clearing of vegetation along the connecting Richmond River valley took place.

***Nurus latipennis* (Sloane, 1903)**

(Figs 4, 24-26, 42)

Castelnaudia latipennis Sloane, 1903.

Nurus latipennis (Sloane): Moore *et al.* (1987).

Type material examined. Moore *et al.* (1987) listed two syntypes from 'Dunoon' and 'Richmond R' in ANIC. *Lectotype* ♀, here designated: 'Dunoon, Richmond R'. It has an old '♀ Type' label on it and Darlington has added his red label, '*Nurus latipennis* Sl HOLOTYPE PJD', but did not publish that action (ANIC). *Paralectotype*, here designated: 'Dunoon, iv.90, Helms' (ANIC).

Other material examined. (116): QUEENSLAND: 1, Bald Mtn area, 1100 m, 38 km E of Warwick, 26.i.1973, I. Titmarsh; 1, s. l., 22-27.i.1971, GBM; 4, s. l., 26-30.i.1973, GBM; 1, s. l., 27-31.i.1972, GBM; 3, Mt Asplenium, 1240 m, 18-20.xii.1992, GBM; 2, s. l., 20.xii.1992-31.iii.1993, GBM; 1, s. l., 29-30.i.1993, GBM; 13, Mt Superbus summit, 1370 m, 8-9.ii.1990, GBM, GIT & HJ; 2, s. l., 23.x.1998, PB & DKY; 2, s. l., 9.i.2009, GBM (1 is EMEC346344) (QM); 2, s. l., 16-18.ii.2002, S.J. Hey & A. Polak (ANIC); 5, Nothofagus Mtn, 1120 m, 25.xi.1982, GBM & DKY; 6, s. l., 1000 m, 4-6.ii.1982, GBM & DKY (QM); 1, s. l., 950 m, 4-6.ii.1982, GBM & DKY(ANIC). NEW SOUTH WALES: 1, Tooloom Plateau, 720 m, via Urbenville, NSW, 16-17.xii.1972, GBM (ANIC); 1, s. l, 16-17.xii.1972, GBM; 3, s. l., 22.x.1972, GBM; 3, s. l., 29.xii.1972, GBM; 1, s. l., 30.i.1973, GBM; 2, s. l., 25.ii.1973, GBM; 2, s. l., 30.ix.1973, GBM; 2, s. l., 11.xi.1973, GBM; 3, s. l., 24.xi.1973, GBM; 1, s. l., 28.ix.1989, GBM; 2, s. l., 19.i.1974, GBM; 1, s. l., 9.ii.1974, GBM; 1, s. l., 31.xii.1973 (QM); 2, s. l., 6.xii.2017, GBM; 4, Big Scrub Loop, Nightcap NP (= Whian Whian SF), 3.i.2011, KWW (1 is EMEC1005747); 1, s. l., 29.i.2008, GBM & FT (EMEC); 1, s. l., 5.v.1973, RIS; 2, s. l., 25–26.xi.1972, GBM; 2, s. l., 29.i.2008, GBM & FT (QM); 1, same data (CBM); 3, s. l., 16.xi-26.xii.1974, GBM & SRM; 1, s. l., 17.vii.2016, GBM (EMEC346343) (QM); 2, s. l., 180 m, 4.ii-9.iv.1993, MG & GC; 3, s. l., 220 m, 4.ii-9.iv.1993, MG & GC; 2, Yabbra SF, 600-900 m, 28º38'S, 152º20'E, 12.xii.1988, Smith, Hines, Pugh, Webber; 2, Beaury SF, 7 km from top end of Tucker Box Trail, 740 m, 4.ii-9.iv.1993, MG & GC; 2, Beaury Creek, 5.xii.1975, FF(AM); 1, Beaury SF, 282º9'Sx152º23'E, 700 m, 15-17.ii/1983, TW & AC (ANIC); 1, Urbenville, 5.xii.1976, FF (AM); 4, Nightcap Range, via Dunoon, 820 m, 16.xi-26.xii.1974, GBM & SRM; 1, s. l., 25.i.1972, GBM; 1, s. l., 820 m, 6.v.1973, IDN; 3, 4 km S. of Bar Mtn, Tweed Range, 29.i.2008, GBM & FT (1 is EMEC346342) (QM); 1, s. l., 28.i.2008, GBM&FT (EMEC); 1, Whian Whian SF, 700', via Dunoon, 25-26.xi.1972, GBM; 1, Dunoon (= Whian Whian SF), xi.72, GBM; 2, Gwydir Hwy, 45 ml. E (of Glen Innes), 3.xii.1963, BPM (ANIC); 2, Acacia Plateau (QDAF).

Type locality. The lectotype is labelled 'Dunoon', which is a small village surrounded by cleared farmland that was formerly rainforest. It is unclear if there are any extant populations of this species in or near Dunoon but it is common only 5.5 km NNE of that location at the Big Scrub Loop Walking Track (28.635ºS x 153.329ºE)

Diagnosis. The range of *Nurus latipennis* is adjacent to those of *N. perater*, *N. atlas*, *N. moorei* and *N. brevis*. Among these it is the only species that has copper, bronze or aeneous colours. The elytra of *N. latipennis* are rather elongate-oval in contrast with all of these species (Fig. 4).

Redescription. *Size*. Overall length 25.0-26.1 mm; greatest width of elytra 10.0-10.5 mm. *Colour*. Dorsal and ventral surfaces with base colour piceous or black; legs, mouthparts and antennae piceous. Pronotum with bronze or copper colour, occasionally mixed with aeneous reflection at lateral and basal

margins. Elytral disc black or with metallic red to copper reflectance and lateral margins of elytra metallic bronze or copper. *Lustre*. Dorsally head, pronotum and elytral margins glossy; elytral disc duller; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines visible at 50x magnification. Clypeal-ocular sulci absent. Ocular ratio 0.70-0.74; eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight or slightly convex, medial four setae separated from each other about half width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth emarginated; constantly with one pair of setae positioned at base of median tooth, occasionally with a second pair of setae laterad of medial pair, rarely with a few other scattered setae. Submentum with two lateral pairs of setae. Gula narrow, width at middle about as wide as width of mentum tooth. Antennae long, antennomere 11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse, sides sinuate and then straight onto base. Marginal bead thick, continuous from apex to base or slightly broadened basally and ending at level of basal impressions; basal margin not bordered, very shallowly emarginated medially; anterior angles very prominently produced; hind angles right-angled or slightly acute and denticulate; base depressed, basal impressions very broad, moderately impressed and not clearly delimited or deeply impressed; transverse linear sulci basad, impressions near basal margin form a wide border or sulci absent. Anterior marginal seta set mesad lateral channel. Seta near hind angle set in lateral bead. Microsculpture of disc visible at 50x magnification, microlines form very irregular transverse mesh. Prosternal process medial impression present near apex deep, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 present, distinctly impressed. Elytral parascutellar setae absent, basal margin sharply bordered. Striae marked with dense, shallow punctulae. Elytra with nine intervals, 2-7 convex, 1, 8-9 scarcely raised. Elytral microsculpture on intervals 1-8 and in striae dense, small, granular, composed of irregular sculpticells giving a dull sheen, slightly glossier in narrow dorsal area of interval's convexity due to shallower microsculpture. Interval 3 with one to three setae. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 24-27 umbilicate setae, somewhat irregularly spaced but more closely set anteriorly and posteriorly. Stria 7 evident apically, with one umbilicate seta. Elytral humeri with small, sharp tooth. Elytra lacking externally visible plica, apiocolaterally internal ridge scarcely apparent. Vestigial flight wing present as a thin strap about 1/6 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia without anterioapical field of setae between antennal cleaner and apical margin in

addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 in both sexes typically with four setae, some individuals with six to nine setae.

Male genitalia. Aedeagus (Figs 24-26) right paramere long, very narrow, tapering to small, sharply hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe narrow, blunt, with a small, rounded denticle. Dorsal ostium wide and rotated to right.

Distribution (Fig. 42). *Nurus latipennis* is the most widespread member of the group but occurs only in rainforest. It occurs sporadically on mountain tops (Mt Nothofagus, Mt Superbus, Mt Asplenium, Bald Mtn) along the Border Ranges west of the Tweed Shield Volcano, then further south on Tooloom and Yabbra ranges, then at both high and low elevations on the Nightcap Range, which is the southern flank of the Tweed Shield Volcano. Barry Moore collected two specimens 110 km further south on the Gibraltar Range, more than halfway to its close sister species *Nurus baehri.* This disjunction between the Queensland Border Ranges and Gibraltar Range is bridged by other flightless Coleoptera such as the dung beetle *Amphistomus trispiculatus* Matthews, 1974.

***Nurus popplei* sp. n.**

(Figs 5, 27-29, 42)

Types. *Holotype* ♂, NEW SOUTH WALES: 'NSW:29.305°Sx151.688°E, 1.1 km N of Torrington, 20July2016, 1160 m, open for. G.B. Monteith 38649'. Deposited in QM, Reg. No. T244815. *Paratypes* (11): NEW SOUTH WALES: 1, Blatherarm Camp, Torrington, 29.252ºS x 151.707ºE, roving, 7.i.2016, L.W. Popple; 1, Silent Grove Rd, Torrington, 29.306ºS x 151.689ºE, 1130 m, 3.xii.2016, GBM, open forest, in burrows (AM); 3, same data (1 is EMEC346325) (QM); 1, 1.1 km N of Torrington, 29.305ºS x 151.688ºE, 1145 m, open forest, 20.vii.2016, GBM (QM); 2, same data (EMEC346326 & EMEC346327) (EMEC); 1, same data (CBM).

Type locality. 1.1 km north of Torrington, NSW (29.305ºS x 151.688ºE)

Diagnosis. *Nurus popplei* is similar to *N. baehri* and *N. brevis* but is only found in the area of Torrington, NSW, rather distant from populations of *N. baehri* and *N. brevis*. Additionally, the basal margin of the elytra is distinctly, deeply concave in *N. brevis* and only shallowly so in *N. popplei* and *N. baehri* (Figs 13-14). *Nurus popplei* is readily separated from *N. baehri* by its pronotal shape and its flatter and duller elytral intervals (Figs 5-6).

Description. *Size*. Overall length 32.3 (31.8-35.5) mm; greatest width of elytra 10.5 (10.4-12.3) mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae black or dark piceous. Pronotum at lateral and basal margins and lateral margins of elytra metallic green, blue or purple. Elytral disc black or rarely strial punctures with a metallic green reflectance. *Lustre*. Dorsally head, pronotum and elytral margins slightly

glossy; elytral disc dull; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines clearly visible at 50x magnification, microlines forming irregular mesh, vertex smooth. Clypeal-ocular sulci absent or represented by very broad, shallow, poorly defined impressions. Ocular ratio 0.72 (0.69-0.73); eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight, medial four setae separated from each other about three-quarters width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth emarginate or bifid; constantly with one pair of setae positioned at base of median tooth, occasionally with a second pair of setae laterad of medial pair. Submentum with two lateral pairs of setae. Gula very narrow, width at middle about as wide as mentum tooth at base. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse, sides not or only very slightly sinuate and convergent onto base. Marginal bead thick, continuous from apex to base; basal margin not bordered, moderately emarginated medially; anterior angles very prominently produced; hind angles right-angled and denticulate or slightly obtusely angled with denticle scarcely apparent; base depressed, basal impressions not apparent or very broad, shallow and not clearly delimited. Anterior marginal seta set mediad of lateral channel. Posterior seta set in hind angle. Microsculpture of disc clearly visible at 50x magnification, microlines forming irregular mesh. Prosternal process with very shallow medial impression near apex, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 absent, present or very shallow or only partially marked. Elytral parascutellar setae absent, basal margin sharply bordered. Striae smooth or marked with irregular, sometimes dense, shallow punctulae. Elytra with nine slightly convex intervals. Elytral microsculpture on intervals 1-8 dense, small, granular, composed of irregular sculpticells giving a dull sheen, without a contrast with strial region or with a narrow dorsal area of interval's convexity contrasting, slightly glossy lustre due to shallow microsculpture. Interval 3 with 0-4 setae, often variable between elytra, typically one seta present in basal and apical thirds of elytron length. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 20-26 umbilicate setae, somewhat irregularly spaced but typically more closely set anteriorly and posteriorly. Stria 7 with one or two setae near apex. Elytral humeri with distinct, sharp or somewhat rounded tooth. Elytra lacking externally visible plica, apiocolaterally internal ridge scarcely apparent. Vestigial flight wing present as a thin strap about 1/5 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia without anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove.

Abdomen. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 with four to six setae.

Male genitalia. Aedeagus (Figs 27-29) right paramere long, broad, narrowed at apex with sharp hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe uniformly rounded. Dorsal ostium very wide and rotated to right.

Female genitalia and reproductive tract. Gonocoxite 2 with one short marginal ensiform and one or two apical nematiform setae. Elongate spermatheca ending in an oval expansion, with a very small spermathecal duct digital diverticulum near base, attached to base of common oviduct. Spermathecal gland connected to spermathecal duct near base by long, narrow duct about 1.5x length of spermatheca; glandular portion elongate ovoid. *Pygidial gland* with large, elongate reservoir; efferent duct very broad; collecting duct connected to dorsal face of reservoir near its base.

Etymology. The specific epithet, *popplei*, is a Latinized version (genitive case) of the surname of Dr Lindsay Popple, who first collected this species and who has made significant discovery of localities for the endangered *Nurus atlas*.

Distribution (Fig. 42). *Nurus popplei* occurs at above 1000 m on an isolated granite plateau surrounding the township of Torrington, 40 km SW of Tenterfield. It is unique in the group in living in open eucalypt woodland with grassy understory and occurs further inland (175 km from coast) than other species.

***Nurus baehri* sp. n.**

(Figs 6, 30-32, 42)

Types. Holotype ♂, NEW SOUTH WALES: 'NSW:30.532°Sx152.362°E, Cunnawara Trail 1350 m 3Jul2017 G.B. Monteith ex burrow, *Nothofagus* RF 39423'. Deposited in QM, Reg. No. T244816. *Paratypes* (135): NEW SOUTH WALES: 1, Point Lookout, 14.x.1973, L. Keogh (ANIC); 17, s. l., 11.xi.1980-16.iii.1981, GBM & SRM, pitfalls; 13, s. l., 22.iii.1980-11.xi.1980, GBM & SRM, pitfalls; 1, s. l., 17.xii.1975, BC; 3, s. l., 20-23.x.1978, GC; 1, New England NP, 25.vii.1980, RR; 2, s. l., 11.xi.1980, GBM; 1, s. l., 1-2.i.1967, GBM; 1, s. l., 8-9.iv.1966, GBM; 2, s. l., *Nothofagus,* 1450 m, 12-13.xi.2008, GBM, ex burrows (QM); 3, s. l., 10.i.1963, BPM; 2, s. l., 1.xii.1963, BPM ; 4, Ebor, NSW, 1.xi.59, BPM; 1, s. l., NSW, 28-30.xii.1974 (ANIC); 4, s. l., xi.1976, FF; 1, s. l., 15.i.1912, RJT; 1, s. l. (AM); 1, s. l., 15.xi.1917; 4, s. l., 15.i.1912; 1, New England NP, Robinsons Knob Trail, 29.xii.1999, L. Toledano; 1, New England NP, Cunnawarra Trail, 3.vii.2017, GBM (1 is EMEC346331 voucher) (QM); 2, s. l., 3.vii.2017, GBM (1 is EMEC346330) (EMEC); 2, s. l., 1130 m, 4.ii-9.iv.1993, MG & GC; 1, Styx R. SF, Cliffs Trail, 3 km S of Pt Lookout, 1350 m, ii-iii, 1993, MG & GC; 2, Styx River SF, bottom end of Cliffs Trail, *ca* 3.8 km NE Oxley Rd, 1180 m, 4.ii-9.iv.1993, MG & GC; 1, New England NP, Cliffs Trail *ca* 2 km S of gate from Pt Lookout Rd, 1300 m, MG & GC; 1, New England NP, top end of Cliffs Trail, 1350 m, 4.ii-9.iv.1993, MG & GC;

3, Marengo SF, 0.5 km NE along Foamy Creek Rd from Chaelundi Rd, 1200 m, 4.ii-9.iv.1993, MG & GC; 1, 7 km N of Pt Lookout, 3.x.1977, DAD; 1, Dorrigo, xii.1953, FF; 1, s. l., i.1974, PZ (AM); 2, s. l., 5.xii.1974, R. Overland; 2, s. l., FF; 1, Majors Point, 20.xii.2002, S.J. Hey & A. Polak (ANIC); 12, s. l., 28.xi.1975, FF; 2, Banksia Point, 20.xi.1975, FF (AM); 3, s. l., 7.i.2011, KWW; 2, Mt Hyland, 3.vii.2017, GBM (EMEC346328 & EMEC346329) (EMEC); 2, s. l., 3.vii.2017, GBM (CBM); 9, Guy Fawkes, xii.1955, FF; 1, Styx River, 13.xi.1976 (AM); 1, Styx River rest area, 26.xii.2000, JB; 1, Styx River SF, Wattle Camp, 13.xi.1982, JD; 1, Blue Hole, 15.ix.1974, P.G. Wong (donated ex UNE colln) (ANIC).

Other material examined. 2, Dorrigo; 4, Ebor (MV).

Type locality. Cunnawarra Trail, NSW (30.532°S x 152.362°E)

Diagnosis. *Nurus baehri* is similar to *N. popplei* but is only found much further south of that and other *Nurus s.str.* species. *Nurus baehri* is readily separated from *N. popplei* by its pronotal shape and more convex and glossier elytral intervals (Figs 5-6).

Description. *Size*. Overall length 26.3 (24.0-27.5) mm; greatest width of elytra 10.8 (10.6-10.8) mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae black or dark piceous. Pronotum rarely all black, typically metallic green or blue at lateral and basal margins. Elytral disc black or with striae and/or intervals with metallic green reflectance, lateral margins of elytra metallic green, blue or purple. *Lustre*. Dorsally head, pronotum and elytral margins glossy; elytral disc duller but intervals dorsally contrastingly glossier; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines hardly visible at 50x magnification, microlines, where evident, forming irregular mesh, vertex smooth. Clypeal-ocular sulci absent or represented by very broad, shallow, poorly defined impressions. Ocular ratio 0.67 (0.67-0.70); eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight, medial four setae separated from each other about three-quarters width from outermost medial seta to lateral seta. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth entire, emarginated or bifid; constantly with one pair of setae positioned at base of median tooth, occasionally with a second pair of setae laterad of medial pair. Submentum with two lateral pairs of setae. Gula very narrow, width at middle about as wide as mentum tooth at base. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse, sides sinuate or subsinuate and then straight or convergent onto base. Marginal bead thick, continuous from apex to base; basal margin not bordered, moderately emarginated medially; anterior angles very prominently produced; hind angles right-angled and denticulate, some with denticle scarcely apparent; base depressed, basal impressions not apparent or very broad and not clearly delimited. Anterior marginal seta set mediad of lateral channel. Posterior seta set in hind angle. Microsculpture of

disc hardly visible at 50x magnification, where evident near base and lateral margins microlines form very irregular mesh. Prosternal process medial impression present near apex, varying from very deep to shallow, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 present, distinctly impressed. Elytral parascutellar setae absent, basal margin sharply bordered. Striae smooth or marked with dense, shallow punctulae. Elytra with nine intervals, 1-8 convex or subcarinate. Elytral microsculpture laterally on intervals 1-8 and in striae dense, small, granular, composed of irregular sculpticells giving a dull sheen, contrasting with broad dorsal area of interval's convexity that has a glossy lustre due to shallow or absent microsculpture. Interval 3 with zero to three setae, often variable between elytra, typically one seta present in basal and apical thirds of elytron length. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 22-28 umbilicate setae, somewhat irregularly spaced but more closely set anteriorly and posteriorly. Stria 7 with one or two setae near apex. Elytral humeri with distinct, sharp or somewhat rounded tooth. Elytra lacking externally visible plica, apiocolaterally internal ridge scarcely apparent. Vestigial flight wing present as a thin strap about 1/5 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia without anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 with four to six setae.

Male genitalia. Aedeagus (Figs 30-32) right paramere long, very broad, narrowed and curved at apex with sharp-hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe rounded. Dorsal ostium wide and rotated to right.

Female genitalia and reproductive tract. Gonocoxite 2 with one short marginal ensiform and two apical nematiform setae (occasionally only one visible, likely due to damage). Elongate spermatheca ending in an oval expansion, with a very a very small spermathecal duct digital diverticulum near base, attached to base of common oviduct. Spermathecal gland connected to spermathecal duct near base by long, narrow duct, about 1.5x length of spermatheca; glandular portion elongate ovoid. *Pygidial* gland with large, elongate reservoir; efferent duct very broad; collecting duct connected to dorsal face of reservoir near its base.

Etymology. The specific epithet, *baehri*, is a Latinized version (genitive case) of the surname of Dr Martin Baehr, Munich, Germany, the foremost and most prolific authority on Australian carabid beetles, having described over 1200 species of Australian carabids to date.

Distribution (Fig. 42). *Nurus baehri* occurs in both rainforests and dense eucalypt forests on the high mountains south-west (Major's Point), south (New England NP) and north (Mt Hyland) of the town of Ebor. Most localities are above 1000 m. There are earlier records from 'Dorrigo', lower and further east, but modern collecting has not located the species near Dorrigo and earlier collectors might have used 'Dorrigo' as a district name that included Ebor.

***Nurus imperialis* (Sloane, 1895)**

(Figs 7, 33-35, 41)

Homalosoma imperiale Sloane, 1895.

Nurus imperialis (Sloane): Tschitschérine (1902).

Type material. *Lectotype*, here designated: '*Homalosoma imperiale* Sl., Moreton Bay' [looks like original drawer label, now on spm] // 'HOLOTYPE' [red, printed] // 'On permanent loan from Macleay Museum, University of Sydney' [printed] // 'Brisbane' [printed], in ANIC. *Paralectotype* ♂, here designated: 'Type/*Trichosternus imperialis* Sl, probably not HOLOTYPE' [printed red label, with 'probably not' handwritten].

Other material eamined. (115): QUEENSLAND: 2, Tamborine Mt, 20.ii.1911, WWF; 2, s. l., 14.ii.1903, WWF; 1, s. l., HJC, xi.24; 1, s. l., RI; 2, s. l., HJC; 1, s. l., AML; 1, s. l., Davidson; 1, s. l., 16.iv.1971, RO; 1, s. l., 6.i.1963, BPM; 4, s. l., 8.x.1910, TGS; 1, s. l., ES; 1, s. l., xii.1950, CO; 1, s. l., ix.28, SRB; 1, s. l., xii.1976, FF; 1, s. l., i.1973, GBM (ANIC); 10, s.l., 1956, FF; 2, s. l., xii.1955, FF; 11, s.l., 22–23.xii.1976, FF; 1, s. l., 3.v.1910, HT; 4, s. l., AML; 5, s. l., x.1924, AM & CG; 1, s.l. (AM); 3, s.l., 28.x.2012, HH; 2, s.l., iii.1921, HAL; 1, s. l., 16.v.1928; 1, s. l., 19.v.1928; 1, s. l., 14.v.1928; 2, s. l., 20.v.1928; 1, s. l., 26.iv.1959, RPJ; 1, s. l., 11.iv.1964, TW; 1, s. l., 11.iv.1964, BC; 1, s. l., AML; 1, s. l.; 1, s. l. (QM); 9, s. l. (MM); 2, s. l., 20.v.1973, RIS; 1, s. l., 1.iii.1979, Agard; 1, s. l., 30.i.1973, GBM; 1, s. l., CJW; 1, s. l., 3.v.1919, HT; 1, s. l., 10.i.1933; 1, s. l. (QDAF); 1, North Tamborine, 9.iii.1992-25.iv.1992, DJC; 2, Palm Grove, Tamborine, 14.xii.1974-22.iii.1975, GBM & SRM; 2, s. l., 22.iii.-25.v.1975, GBM & SRM; 2, s. l., 25.vi.1972, GBM; 1, s.l, 30.x.1972, GBM; 1, s. l., 23.viii.2007, GBM (QM); 1, s. l., 23.viii.2007, GBM & FT; 2, s. l., 2016, GBM (EMEC347347, EMEC346348) (EMEC); 1, s. l., 15.vi.1971, GBM; 1, McDonald Park, Mt Tamborine, 26.xi.1982, JD; 1, South Queensland; 1, 'Endeavour R.' [spurious]; 2, no data (ANIC); 1, Witches Falls, Mt Tamborine, 28.ii.1960, J. Bryan; 3, no data; 1, Queensland (QM); 1, no data (QDAF); 1, no data (AM).

Type locality. 'Moreton Bay' was the name used for the first Queensland settlement prior to it being named Brisbane in 1834 and was applied as a locality name for many early collections from the broader SE Queensland region that includes Tamborine Mountain, 55 km south of Brisbane. This species is well surveyed and occurs only within a 5 km radius at the northern end of Tamborine Mountain.

Diagnosis. The prominent metallic colour (Figs 7-8) and the patch of additional setae near the apex of the protibiae (Fig. 9) separate *N. imperialis* and *N. moorei* from all other *Nurus s.str.* species. In addition to the characteristics in the key, *N. imperialis* differs from *N. moorei* by having

much flatter elytral intervals, especially the basal half, and the base of interval 2 is usually not raised at all, whereas N. *moorei* has more convex intervals and interval 2 is usually similarly convex to other intervals. Distribution is also distinguishing, with *N. imperialis* found only on Mt Tamborine, 30 km north of the range of *N. moorei* (Fig. 41).

Redescription. Size. Overall length 28.5-33.5 mm; greatest width of elytra 11.7-13.4 mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae black or piceous, usually piceous proximally. Head dorsally, pronotum and lateral margins of elytra metallic green, copper or aeneous colour. Elytral disc black. *Lustre*. Dorsally head, pronotum and elytral margins very glossy; elytral disc dull; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines not or scarcely visible at 50x magnification, vertex smooth. Clypeal-ocular sulci represented by broad, shallow, poorly defined impressions that are parallel and end at level of anterior supraorbital setae. Ocular ratio 0.73-0.76; eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight and raised medially, medial four setae separated from each other half or less width from outermost medial seta to lateral seta, slightly wider gap between medial setae. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth emarginate or bifid; constantly with one pair of setae positioned at base of median tooth, frequently with a second pair of setae laterad of medial pair. Submentum with two lateral pairs of setae. Gula very narrow, width at middle about as wide as mentum tooth at base. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse to linear, sides sinuate or subsinuate and straight onto base. Marginal bead thick, continuous from apex to base; basal margin not bordered, moderately to deeply emarginate; anterior angles prominently produced; hind angles right-angled; basal impressions shallowly impressed, very broad, not sharply delimited. Anterior marginal seta set mediad, touching lateral channel. Seta at hind angle touching or in basal bead. Microsculpture of disc visible at 50x magnification as irregular mesh. Prosternal process with shallow or deep medial impression near apex, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 present. Elytral parascutellar setae absent, basal margin sharply bordered. Striae marked with dense, shallow punctulae. Elytra with nine very slightly convex intervals. Elytral microsculpture on intervals 1-8 dense, small, granular, composed of irregular sculpticells giving a dull sheen. Interval 3 with three to four setae. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 28-32 umbilicate setae, somewhat irregularly spaced but typically more closely set anteriorly and posteriorly. Elytral humeri with distinct, dorsally oriented

tooth. Elytra lacking externally visible plica, apiocolaterally with a low internal ridge present. Vestigial flight wing present as a thin strap about 1/5 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia with anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 with four to eight setae.

Male genitalia. Aedeagus (Figs 33-35) right paramere long, very narrow, tapering to small, sharply hooked denticle, left paramere broadly rounded at apex, conchiferous; tip of median lobe narrow, blunt, with a small, rounded denticle. Dorsal ostium wide and rotated to right.

Distribution (Fig. 41). *Nurus imperialis* is restricted to the small (10 km long) Tamborine Mountain, a northern outlier plateau of the Tweed Shield Volcano, isolated by resistant basalt cliffs and the convergence of the valleys of the Coomera and Albert Rivers between it and the rest of the volcano (Willmott 2004). Most specimens are simply labelled 'Mt Tamborine' but Fricke (1965) noted that the species occurs only at the northern end of the plateau. The top of the plateau is cleared now and rainforests persist only in reserves below the rim. Modern surveys by GBM show the species still survives in Palm Grove, McDonald Park, Curtis Falls and Witches Falls National Parks, all of them in the northern half of the plateau.

***Nurus moorei* sp. n.**

(Figs 8-10, 36-38, 41)

Types. *Holotype* ♂, QUEENSLAND: 'Mt Gannon via West Burleigh, 700 m, SE Qld 1July-2 Nov 1986 D. Cook & G. Monteith Rainforest Pitfalls' // 'QM Reg. No. T89256'. Deposited in QM. *Paratypes* (108): QUEENSLAND: 4, Albert River, right branch, 340 m, 1.xi.1975-30.x.1976, GBM & SRM; 4, s.l., 4.iv.-8.x.1976, GBM & SRM; 2, Albert River, right branch, 420 m, 1.ii.1975, NG; 2, Albert River, s. l., 1.xi.1975, GBM & SRM (QM); 1, s. l., 1.xi.1975, GBM & SRM (ANIC); 1, Albert River, Lamington, 2 km E of YHA hostel, 1.ii.1975 (QDAF); 1, Bithongabel, Lamington NP, 1160 m, 27.ix.1975, GBM; 1, Mt Cougal, 500 m, 17.i.1989, GBM; 1, s. l., 19.xi.1986, GBM, DJC & GIT; 2, Mt Gannon summit, 700 m, 2.xi.1986-18.i.1987, GBM & DJC; 3, Mt Gannon summit, 700 m, 1.vii-2.xi.1986, GBM & DJC; 3, Mt Gannon 400 m, 1.ix.1985, GBM & DJC; 1, s. l., 2.xi.1986-18.i.1987, GBM & DJC; 12, s. l., 18.i.-5.1v.1987, GBM & DJC; 2, Mt Gannon, 500 m, 28.198°S x 153.317°E, 29.xi.2010, KWW, GBM & DJC (QM); 5, Mt Gannon, 29.xi.2010, KWW (1 is EMEC10003800); 2, Christmas Creek, 360 m, 28.298°S, 153.096°E, 1.i.2018, GBM; 2, Numinbah Arch, 2.xii.2017, GBM (EMEC); 3, Tomewin Range, 500 m, 17.x.1988, GBM; 4, s. l., 16.v.1989, GBM, pitfall traps; 1, s. l., 19.x.1989, GBM; 1, Upper Tallebudgera Creek, 560 m, 9.xii.1984, GBM & DJC; 5, s. l., 9.xii.1985, GBM & DJC; 1, s. l., 1.iii-3.vii.1985, DJC; 18, s. l., 8.i-17.iii.1985, GBM, DJC & GIT (QM); 3, Upper Tallebudgera Creek, 500 m, 8.i.1985, GBM; 7, s. l. 19.xi.2007, GBM & FT (2 are EMEC346345 & EMEC346346) (QM); 2, same data (CBM); 2, same data (AM); 3, Rat-a-Tat Hut, Lamington NP, 28º18'S,153º08'E, 920 m, 6.vii.1998, GBM (QM); 2, s. l., 20.viii.1952, JB; 1, National Park, Q., A.H. Chisholm (ANIC);

1, Macpherson Range, 22.x-5.xi.1926 (QM). NEW SOUTH WALES: 1, Tweed R., HJC (ANIC); 1, Tweed R, NSW; 1, no data, Reg. No. K259480 (AM); 2, Hayters Hill, 115 m, 28.673ºS, 153.587ºE, 28.iii.2018, GBM; 1, Lower Minyon Valley, 125 m, 28.627ºS, 153.393ºE, 22.viii.2018, DC (QM).

Type locality. Mt Gannon via West Burleigh, 700 m, SE Qld (28.202ºS x 153.314ºE).

Diagnosis. The prominent metallic colour and additional setae near the apex of the protibiae (Fig. 9) separate *N. moorei* and *N. imperialis* from all other *Nurus s.str.* species. In addition to the characteristics in the key, *N. imperialis* differs from *N. moorei* by having much flatter elytral intervals, especially the basal half, and the base of interval 2 is usually not raised at all, whereas N. *moorei* has more convex intervals and interval 2 is usually similarly convex to other intervals. Distribution is also distinguishing, with *N. imperialis* only found on Mt Tamborine, 35 km north of the range of *N. moorei* (Fig. 41).

Description. Size. Overall length 25.8 (24.5-29.5) mm; greatest width of elytra 11.9 (10.1-12.5) mm. *Colour*. Dorsal and ventral surfaces with base colour black; legs, mouthparts and antennae black or piceous, usually piceous proximally. Head dorsally, pronotum and lateral margins of elytra deep metallic green or slightly bluish green colour. Elytral disc black or with intervals with a slight green reflectance and striae with a slight coppery reflectance. *Lustre*. Dorsally head, pronotum and elytral margins very glossy; elytral disc dull; ventrally moderately glossy. *Head*. Dorsal microsculpture with microlines not or scarcely visible as irregular mesh at 50x magnification, vertex smooth or with very shallow wrinkles near eyes and base. Clypeal-ocular sulci represented by broad, shallow, poorly defined impressions that are parallel and end at level of anterior supraorbital setae. Ocular ratio 0.74 (0.70-0.74); eyes large, rounded. Mandibles long, abruptly hooked apically, scrobe glabrous. Labrum anterior margin straight or very slightly convex and raised medially, medial four setae separated from each other about three-quarters width from outermost medial seta to lateral seta, slightly wider gap between medial setae. Mentum long, deeply emarginate with parallel, prominent lateral lobes; median tooth prominent, tooth entire, emarginate or bifid; constantly with one pair of setae positioned at base of median tooth, frequently with a second pair of setae laterad medial pair, often only unilaterally. Submentum with two lateral pairs of setae. Gula very narrow, width at middle about as wide as mentum tooth at base. Antennae long, antennomeres 10-11 extended beyond pronotal base, antennomeres 5-11 elongate, apices of 4-11 densely pubescent, 2-4 compressed at base. *Thorax*. Pronotum transverse to linear, sides sinuate or straight onto base. Marginal bead thick, continuous from apex to base; basal margin not bordered, moderately to deeply emarginate; anterior angles prominently produced; hind angles right-angled; basal impression deeply impressed, very broad, not sharply delimited. Anterior marginal seta set mediad of lateral

channel. Seta at hind angle touching or in basal bead. Microsculpture of disc not or scarcely visible as irregular mesh at 50x magnification. Prosternal process with deep medial impression near apex, prosternum apically plurisetose. Metepisternum and metepimeron very short. Elytral striae complete, broadly and shallowly impressed. Parascutellar striae and angular base of stria 1 present but frequently very shallow or only partially marked. Elytral parascutellar setae absent, basal margin sharply bordered. Striae marked with dense, shallow punctulae or nearly smooth. Elytra with nine intervals. Elytral microsculpture on intervals 1-8 dense, small, granular, composed of irregular sculpticells giving a dull sheen. Interval 3 with four [rarely three or five] setae. Interval 9 and marginal channel microsculpture composed of flat, very reflectant sculpticells contrasting with dull discal microsculpture. Interval 9 with 28-32 umbilicate setae, somewhat irregularly spaced but typically more closely set anteriorly and posteriorly. Elytral humeri with distinct, dorsally oriented tooth. Elytra lacking externally visible plica, apiocolaterally with a low internal ridge present. Vestigial flight wing present as a thin strap about 1/5 elytral length. Male and female protarsi symmetrical and ventrally glabrous. Protibia with anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove. *Abdomen*. Abdominal ventrites smooth, 2-5 with a row of paramedial setae. Apical margin of ventrite 6 with four to six setae.

Male genitalia. Aedeagus (Figs 36-38) right paramere long, thin, sharply hooked at apex, left paramere broadly rounded at apex, conchiferous; tip of median lobe rounded, with small blunt denticle. Dorsal ostium very wide and rotated to right.

Female genitalia and reproductive tract. Gonocoxite 2 with three marginal ensiform and one or two apical nematiform setae. Elongate spermatheca ending in an oval expansion, with a prominent spermathecal duct digital diverticulum near base, attached to base of common oviduct. Spermathecal gland connected to spermathecal duct near base by long, narrow duct, nearly 2x length of spermatheca; glandular portion very elongate. *Pygidial gland* with large, elongate reservoir; efferent duct very broad; collecting duct connected to dorsal face of reservoir near its base.

Etymology. The specific epithet, *moorei*, is a Latinized version (genitive case) of the surname of the late Dr Barry P. Moore. This species is so named to honour his contributions to Australian carabid beetle taxonomy and chemical ecology.

Distribution (Fig. 41). *Nurus moorei* occurs in rainforests of valleys and low outlier ridges peripheral to the Lamington and Springbrook plateaux in the northern half of the Tweed Shield Volcano, as well as in two newly discovered sites 50 km further south (Hayters Hill and Lower Minyon Valley) on the extreme southern margin of the Volcano remnants. Curiously,

it is absent from the well collected northern part of the Lamington massif, but repeated collections have been made at two remote southern localities above 900 m altitude on the same plateau (Bithongabel and Rat-a-Tat).

Key to adults of *Nurus* s. str. species

1 Protarsomeres 1 and 2 or 1 to 3 with pads of squamose setae ventrally (some males) (Figs 11-12) …..... 2

1' Protarsomeres without pads of squamose setae ventrally (males or females) (Fig. 10) …….. 3

2(1) Protarsomeres 1-2 with pads of squamose setae ventrally (males) (Fig. 11); elytral intervals more or less equally developed …..... *Nurus atlas*

2' Protarsomeres 1-3 with pads of squamose setae ventrally (males) (Fig. 12); odd elytral intervals much more prominently convex than even intervals ..... *Nurus perater*

3(1') Protibia with anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove (Fig. 9); head with metallic reflection ……... 4

3' Protibia without anterioapical field of setae, longitudinal row of two to five setae above antennal cleaner groove; head without or rarely with metallic reflection …..... 5

4(3) Head, pronotum and elytral margins pure metallic green; usually smaller, length 24.5-29.5 mm …..... *Nurus moorei*

4' Head, pronotum, and elytral margins bronze, aeneous or variably red to green metallic; usually larger, length 28.5-33.5 mm; restricted to Mt. Tamborine, Qld …..... *Nurus imperialis*

5(3') Protarsomeres 1-2 with a field of medial setae, protarsomere 1 typically with eight or more setae, 2 with three to four, rarely one side with only one; Lismore-Casino region of NSW (Figs 40, 42) …..... 6

5' Protarsomere 1 with a field of four or more medial setae, protarsomere 2 with none or rarely with only one on one side; not found in the Lismore-Casino region of NSW .....…….. 7

6(5) Elytral basal margin deeply curved (Fig. 13); size smaller, 23.5-28.2 mm; black or with metallic reflection laterally on the pronotum and elytral margins that is blue, violet or rarely green; pronotum cordate, lateral margins sinuate, width across anterior angles wider than distance across basal angles; pronotal basal margin distinctly concave; basal margin of elytra clearly sinuate; occurs from Lismore west to Mallanganee (Fig. 42) …… .*Nurus brevis*

6' Elytral basal margin shallowly curved (Fig. 14); size larger, length 28.5-30.5 mm; typically with a green metallic reflection laterally on the

pronotum and elytral margins; pronotum subquadrate, width across anterior angles only slightly wider than distance across basal angles; pronotal basal margin very slightly concave; basal margin of elytra almost straight; distribution restricted to near Alstonville, east of Lismore (Fig. 40) ..... *Nurus atlas*

7(5') Larger, length 31.8-35.5 mm; black; elytra parallel-sided; head relatively very large; abdominal ventrites 3-5 with one pair of paramedial setae only; odd elytral intervals much more prominently convex than even intervals ..... *Nurus perater*

7' Smaller, length 24.0-29.5 mm; colour black but frequently with metallic reflection on pronotum and elytral margins; elytra elongate-ovoid; head of average size for genus; abdominal ventrites 3-5 with numerous setae in a row in addition to paramedial setae on at least one ventrite, usually on all ventrites; elytral intervals more or less equally developed …….. 8

8(7') Anterior and posterior supraorbital setae separated from supraocular sulcus by the width of the setal fovea or more distant; metallic colour aeneous or bronze ..... *Nurus latipennis*

8' Anterior supraorbital setae less than the width of the setal fovea from or touching the supraocular sulcus; the posterior supraorbital seta position variable, but usually also one fovea width or less from the sulcus; metallic colour, when present, green, blue or rarely purple 9

9(8') Pronotal lateral margins sinuate; elytral disc with intervals clearly convex or subcarinate with a wide dorsal area of the interval's convexity with a contrasting glossy lustre due to the lack of or very shallow microsculpture; male genitalia Figs 30-32 …… *Nurus baehri*

9' Pronotal lateral margins subsinuate or nearly straight on the base; elytral disc with intervals low convex without a contrast with the strial region or with a narrow dorsal area of the interval's convexity scarcely contrasting, slightly glossy lustre due to shallow microsculpture; male genitalia Figs 27-29 .....…….. *Nurus popplei*

Discussion

The resulting phylogenetic trees for *Nurus* s. str. species have three well-supported clades, *viz.* (*N. moorei* + *N. imperialis)*, (*N. perater* + *N. atlas)* and (*N. latipennis* + *N. brevis* + *N. popplei* + *N. baehri*). The presumed morphological apomorphies of the *N. moorei* + *N. imperialis* clade include the anterioapical field of setae between antennal cleaner and apical margin in addition to longitudinal row of setae above antennal cleaner groove on the protibia (Fig. 9). This state is not found in any other *Nurus* s. str. species. Their clear metallic colour, especially on the head, similar form of the body (Figs 7-8) and similar male genitalia (Figs 33-38) are all consistent with this sister-group relationship and distinctiveness of the pair relative to other

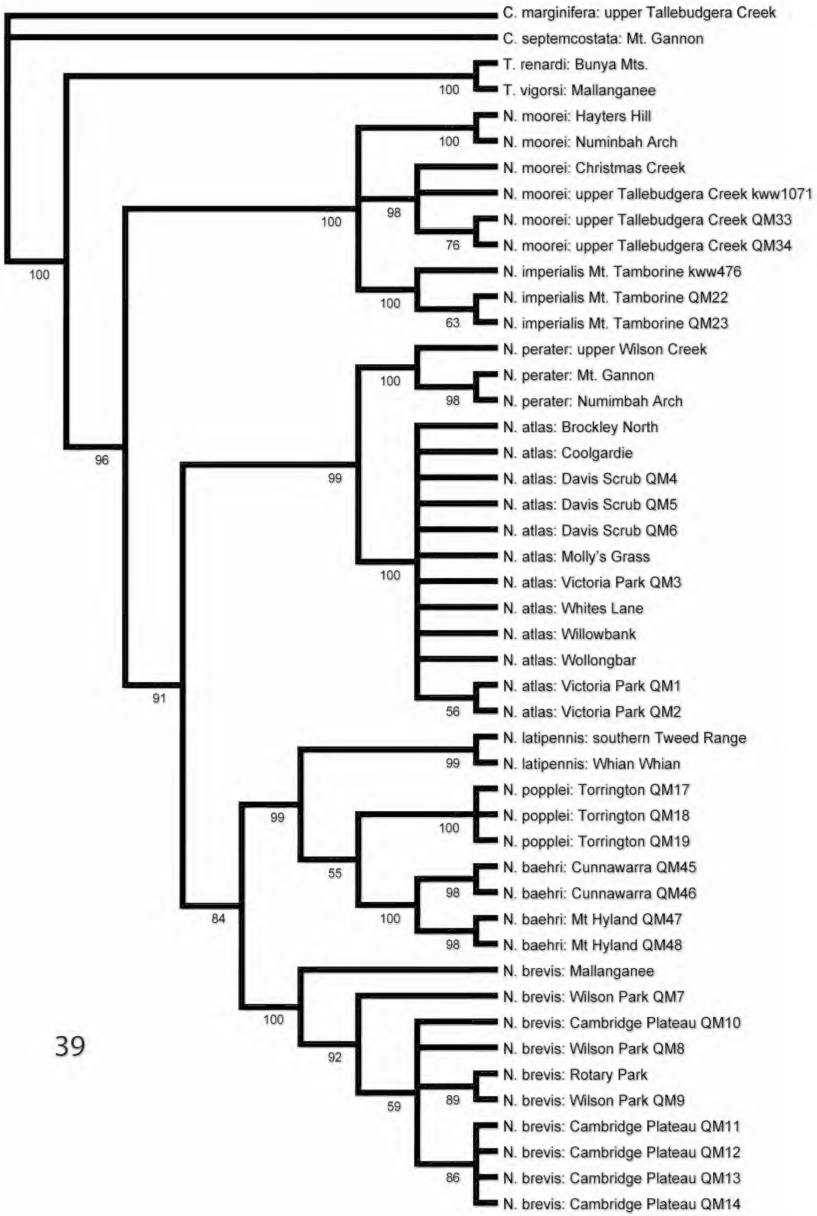
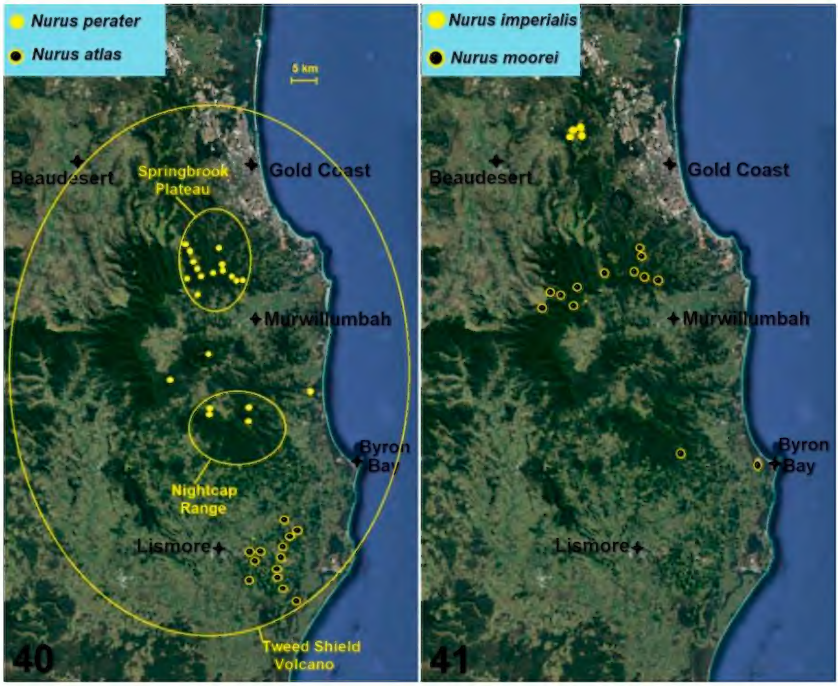


Fig. 39. Strict consensus of 20 trees for *Nurus* s. str. species. Numbers below branches are jackknife scores for clades scoring >50.

species. While recognisably different, their close similarity suggests a very recent split between the two species. In fact, samples of *Nurus moorei* do not form a monophyletic group in the strict consensus or jackknife tree (Fig. 39). Among the 20 parsimony trees, 10 place *N. moorei* from Hayters Hill and Numinbah Arch as a sister group to the remaining *N. moorei* OTUs and 10 place them sister to the *N. imperialis* clade, the latter arrangement making *N. moorei* paraphyletic. Neither placement is well supported. The paraphyletic arrangement finds support from only a few characters at the third positions of COI and this situation contrasts with the small number of synapomorphies in CAD that support *N. moorei* monophyly. Paraphyly within species for mtDNA sequences is common (Funk and Omland 2003) and monophyly is neither a necessary nor sufficient condition for species recognition (Knowles and Carsten 2007). Additionally, consistent differences between *N. moorei* and *N. imperialis*, including the form of the male genitalia (Figs 33, 36), colour of the dorsum, form and relative size of the elytra (Figs 7-8) and distinctly separated distributions (Fig. 41), all support separation and recognition of the two species.



Figs 40-41. Distribution maps for *Nurus* spp: (40) *Nurus perater* and *N. atlas;* (41) *N. imperialis* and *N. moorei.* On Fig. 40 the approximate boundaries of the Tweed Shield Volcano, the Springbrook Plateau and the Nightcap Range are shown.

A clade of *N. perator* + *N. atlas* is also well supported and, while in general body form they are very divergent, they share the condition of having the squamous vestiture on the ventral surface of the male tarsomeres, which is consistent with their placement. *Nurus perater* exhibits remarkable convergence with the general form of some species of *Trichosterus*, particularly, as noted by Sloane (1923), *T. renardi*. However, *N. perater* has a glabrous mesosternum and an arrangement of elytral striae near the apex unlike *Trichosternus* species, both states shared with other *Nurus* s. str. species. Both the DNA sequence data and details of the morphology support this result.

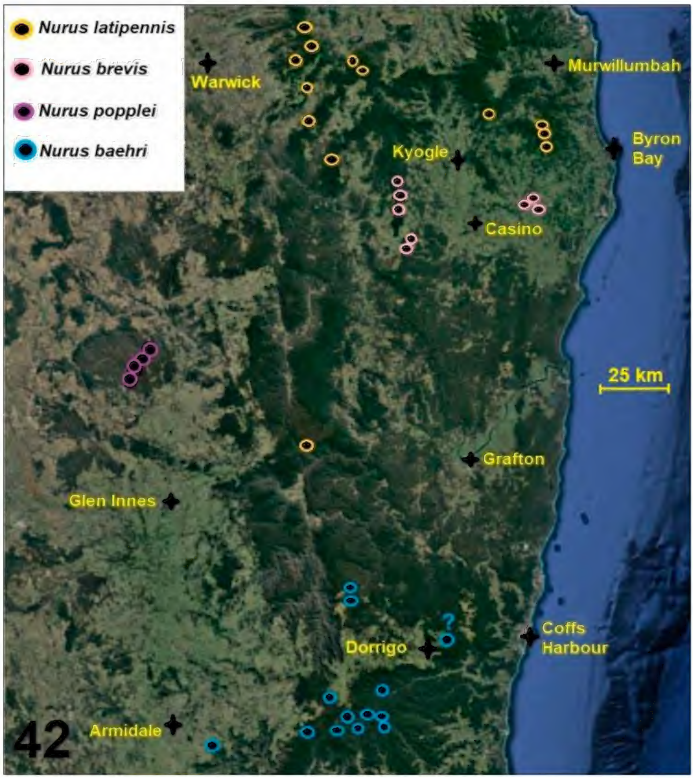


Fig. 42. Distribution map for *Nurus brevis, N. latipennis, N. popplei* and *N. baehri.*

The remaining four species form a clade that includes the most southerly and the most inland distributions. *Nurus popplei* and *N. baehri* are at these distributional extremes and are widely separated, the most widely separated of any species pair. While the support for this relationship is modest (jackknife of 55, Fig. 39), the form of the parameres (Figs 29, 32) is very similar and distinct from all other *Nurus* s. str. species.

The greatest diversity of *Nurus* s. str. occurs across the complex mountain systems that have resulted from the erosion and dissection of the 100 km diameter Tweed Shield Volcano (Wilmott 2004; Fig 40). Six of the eight species occur there and four are restricted to this region. With rare exception, the distributions of *Nurus* s.str. species are mutually exclusive, with usually only one species occurring at a single locality. The exception is the case of *Nurus perater* and *N. moorei*, which co-occur at low elevations to both the east (Tallebudgera Valley) and west (Numinbah Valley) of the Springbrook Plateau (Figs 40-41). However, at fine scale, their ranges are found to be contiguous, rather than overlapped, at those localities. At Numinbah, *N. perater* is found on the eastern side of Cave Creek while *N. moorei* is on the western side. In the Upper Tallebudgera Valley, sampling along a walking track reveals that a continuous occurrence of *N. perater* burrows changes abruptly to continuous occurrence of *N. moorei* and then back again to *N. perater* on a scale of several hundred meters, with no mixing. In the Nightcap Range (Fig. 40), which is the southernmost remnant block of the Tweed Shield Volcano, three species, representing all three clades, occur, but they are segregated into four discrete drainage systems. *Nurus perater* occurs at both the western (Mts Nardi and Matheson at the head of the Turntable Creek valley) and the eastern (head of Wilsons Creek valley) ends of the Nightcap Range. *Nurus latipennis* occurs at high and low elevations in the Rocky Creek valley and *N. moorei* occurs in the lower Minyon Creek valley, both being between the occurrences of *N. perater*. These four drainages are separated by about only 5 km between each.

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THE DISTRIBUTION AND CONSERVATION OF THE ENDANGERED ATLAS RAINFOREST GROUND-BEETLE, *NURUS ATLAS* (LAPORTE, 1867) (COLEOPTERA: CARABIDAE), IN NORTH-EAST NEW SOUTH WALES

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Abstract

Surveys for the Atlas Rainforest Ground-beetle, *Nurus atlas* (Laporte) (listed as endangered in New South Wales), were undertaken in its highly restricted rainforest habitat on the Alstonville Plateau in north-east New South Wales. Seven new populations were found, taking the known number of extant populations from four to 11. All populations are within a radius of 10 km of Alstonville, although it is unlikely that there is much connectivity between them. A range of potential threats were identified, including over-abundant Australian Brush-turkeys, weed invasion, cane toads, stormwater run-off and flying-fox camps. Despite finding the new populations, *N. atlas* still appears to be highly threatened, with management intervention probably required to maintain some populations.

Introduction

Nurus atlas (Laporte, 1867) is a large (length 30-35 mm), flightless carabid beetle (Fig. 1) first described in 1867. The type specimens are in the Genoa Museum, Italy and the type locality is simply 'Clarence River', a broad district name used by collectors early in the European settlement of NE New South Wales (NSW). There are seven other species in the genus *Nurus* sensu stricto, ranging over 300 km from the southern limit in the Ebor area north to Mt Tamborine in southeastern Queensland (Will and Monteith 2018).

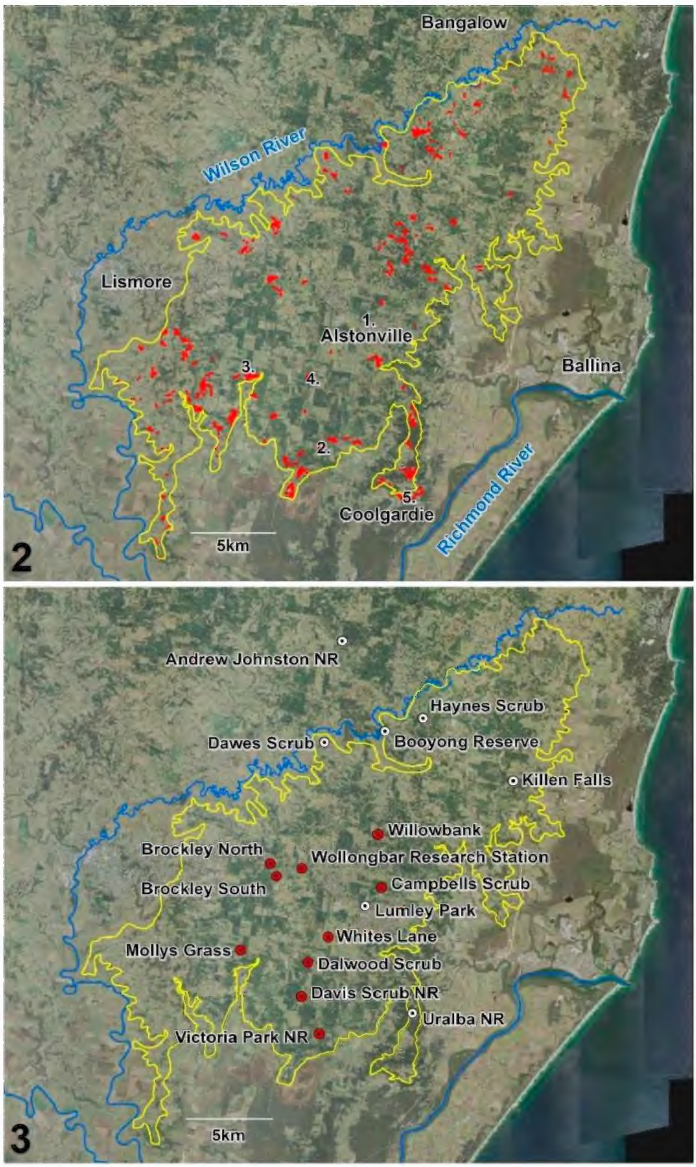
Fig. 1. *Nurus atlas* female from Molly's Grass rainforest remnant, Tregeagle. Overall length 30-35 mm (Photo: D. Charley).

Species of *Nurus* Motschulsky are rarely obtained by traditional collecting methods and, by the 1970s, there were still only a few old undated specimens of *N. atlas* from unspecified broad localities in Australian museums. In 1973-75, G.B. Monteith, then at the University of Queensland, undertook a long-term pitfall trap survey of rainforest invertebrates in southern Queensland and northeastern NSW. During this project, *N. atlas* was trapped in rainforest remnants east of Lismore (at Victoria Park Nature Reserve (NR) and Lumley Park, Alstonville: Fig. 2), providing the first precise locations for the species more than a century after it was first collected and described (Will and Monteith 2018). Initial confirmation of the identity of the 1973-75 specimens of *N. atlas* was by the late carabid specialist, Dr Barry Moore, to whom this special issue of *Australian Entomologist* is dedicated.

The presence of *N. atlas* in Victoria Park NR was used to justify adding the area to the National Estate Register (Greenslade 1994). This was followed in 2001 by the listing of *N. atlas* as an endangered species in NSW (Scientific Committee 2001a). During the same survey by Monteith, another little-known species, *Nurus brevis* Motschulsky, 1865, was rediscovered in two reserves within Lismore City, just 14 km west of the *N. atlas* sites. Similarly, this led to the addition of Rotary Park in Lismore to the National Estate Register (Greenslade 1994) and to the listing of *N. brevis* as endangered in NSW (Scientific Committee 2001b). Both species were included in *Threatened Species of the NSW Upper North Coast* (National Parks and Wildlife Service 2002) and listed in a compilation of the invertebrates of the Gondwana Rainforests World Heritage Area (Williams 2002).

During the 1973-75 surveys, it was discovered (G.B. Monteith pers. obs.) that all species of *Nurus* construct burrows with a distinctive appearance (Figs 4-5) and specimens can be reliably collected by searching for and excavating these burrows. It was also found that males and lesser numbers of females can be trapped in long-term pitfall traps, provided they are operated during the wet season when males leave their burrows, perhaps in search of females, or when newly emerged adults are seeking a burrow site. These observations enabled, for the first time, the gathering of reliable distribution data on these poorly known species.

Subsequently, *N. atlas* was found in Molly's Grass near Tregeagle in 1982 by D.K. Yeates, in Davis Scrub Nature Reserve in 2008 by G.B. Monteith and F. Turco and at Coolgardie, north of Wardell, in 2016 by Lindsay Popple (all Queensland Museum records). At Coolgardie, the species is being monitored at a site adjacent to the Pacific Highway upgrade (Roads and Maritime Services 2015). These locations are all within a 10 km radius and on or adjacent to the Alstonville Plateau in some of the few remaining remnants of the extensive subtropical rainforest called the 'Big Scrub' that once covered the region (Frith 1977). The highly restricted extent of the habitat available to *N. atlas* underlines its endangered status.



Figs 2-3. The Alstonville Plateau study area, outlined in yellow; see text for details: (2) rainforest remnants (red) and the location of the five *Nurus atlas* populations known prior to this survey: 1. Lumley Park, 2. Victoria Park NR, 3. Molly's Grass, 4. Davis Scrub NR and 5. Coolgardie; (3) the 17 locations searched in this project, illustrating those surveys where *N. atlas* was found (red) and not found (white).

Although our understanding of the general taxonomy of *Nurus* has recently been transformed (Will and Monteith 2018), for *N. atlas* there has been no change. This was foreshadowed in the preliminary findings of the taxonomic study and is one reason why *N. atlas* was the species chosen for this study. It was also chosen over its endangered congenor, *N. brevis,* because the conservation of *N. atlas* was considered more urgent.

The objective of this study was to investigate the distribution of *N. atlas* through a detailed survey of known and potential habitat in rainforest remnants of the Alstonville Plateau, to identify new habitat areas, to map the exact location of as many burrows as possible and to briefly report on habitat conditions (including threats) at each site.

Study Area

The Alstonville Plateau study area (Fig. 2) was mapped using the boundary of the Lismore Basalt geological unit (Dept of Mineral Resources 2011) because soil type is likely to play a major role in determining the distribution of a burrowing species such as *N. atlas.* There are three modifications to that boundary: (i) a small area is excised at Lismore City where a soil change corresponds to a change in species to *N. brevis*; (ii) the disjunct Lismore Basalt outcrops in the southeast are represented by a continuous extension of the study area down to Coolgardie; and (iii) the study area does not extend past Bangalow in the north as another species, *N. moorei* Will & Monteith, 2018, occurs further to the north at Hayters Hill (Will and Monteith 2018). The study area corresponds roughly to the area within the 50 m elevation contour defining the plateau, all of which is below 200 m (maximum of 199 m at Tregeagle), and is similar to previous delineations of the Alstonville Plateau (*e.g.* Brodie *et al*. 2002).

Rivers and inundation from flooding in low-lying alluvial areas might represent barriers to the species. The Plateau is therefore a naturally defined study area as it is bounded by the Wilson River to the north-west, the Richmond River to the south and south-east and the coastal plain to the east.

The study area is 33,950 ha and contains 159 remnants of lowland subtropical rainforest (figures obtained from the partly revised mapping of Office of Environment and Heritage 2010). These ranged in size from 0.2 ha to 38.1 ha (averaging 4.4 ha). The total area of mapped rainforest is 700 ha, comprising only 2% of the study area (Fig. 2). Most of these remnants are comprised of regrowth and the introduced Camphor Laurel, *Cinnamomum camphora* ((L.) J. Prestl.), is generally a common component. The other 98% of the landscape is nearly all cleared and used for intensive agriculture and for urban and rural residential development.

It was beyond the scope of this study to survey most of these remnants, the majority of which are on private property. Many are disturbed, contain abundant weeds and are unlikely to be *N. atlas* habitat. Earlier mapping

identified about 33 mature Big Scrub remnants in the study area (Parkes *et al.* 2008). These were considered to be the most likely *N. atlas* habitat and were therefore targeted for survey. The 17 remnants examined in this project are shown in Fig. 3 and listed in Tables 1 and 2. Of these, Willowbank, Wollongbar Research Station, Lumley Park, Davis Scrub NR, Victoria Park NR, Uralba NR, Booyong Reserve, Andrew Johnston NR and Killen Falls are on public tenure and the remaining eight sites are on private property.

Methods

Surveys were undertaken by DC in 12 of the sites (Lumley Park, Willowbank, Campbells Scrub, Whites Lane, Wollongbar Research Station, Dalwood Scrub, Brockley North, Brockley South, Molly's Grass, Davis Scrub NR, Victoria Park NR and Uralba NR; Table 1) between March and April 2018 (Charley 2018). Five additional northern sites were more briefly examined: Dawes Scrub and Haynes Scrub (by DC in September 2018), Killen Falls (MA in September 2018) and Booyong Reserve and Andrew Johnston NR (G.B. Monteith in November 2017).

Surveys for the characteristic *Nurus* burrows were conducted in potential rainforest habitat. The burrows are found immediately beneath the downhill edge of rocks, logs and exposed roots and have a cleared and well maintained 'stage' directly outside the entrance (Figs 4-5). It can be assumed reliably that each such active burrow will contain one adult beetle (G.B. Monteith pers. comm.). A Garmin GPSMAP 64s was used to record a track log of the search as well as point locations for each burrow. Details of the burrow substrate and shelter type (*i.e.* rock, log or root) were also recorded. All but three sites were searched by the same observer (DC), providing a consistent dataset.

Figs 4-5. Burrow entrances of adult *Nurus atlas*: (4) burrow at Wollongbar Research Station beneath the edge of a root, with cleared and maintained stage. Coin is 30 mm diameter; (5) burrow at Whites Lane beneath crossed roots with cleared stage (Photos: D. Charley).

Where possible, each location was walked in a grid pattern (at an approximate spacing of 2-4 m) to ensure that all potential habitat was systematically searched, although impenetrable vine thickets often prevented

complete coverage. Due to time constraints and the primary objective of identifying new populations (in this paper a 'population' refers to the population of ground-beetles occupying a discrete habitat remnant), more limited meandering searches were undertaken in some areas. These included Davis Scrub NR and Victoria Park NR where *N. atlas* was already known and some other locations to the north of the core distribution (Dawes Scrub, Haynes Scrub, Booyong Reserve, Andrew Johnston NR and Killen Falls). In most new locations, a burrow was excavated and a specimen obtained to confirm the identity of the species and to provide genetic data.

Data collected during the survey included time, date, GPS track, GPS location for each burrow and basic habitat and threat assessment. In addition, notes on possible site management were recorded. All field data were entered into an ARCMAP 9.3 GIS database. The burrow locations were uploaded to the BioNet, the atlas of NSW wildlife.

Results

The ten days of field surveys by DC between 1 March and 6 April 2018 located 1875 burrows (Table 1). Burrows were recorded at 10 of the 17 survey locations, including seven new locations (Table 1 and Fig. 3). All sites were in lowland subtropical rainforest and were on the red krasnozem soils (ferrosols) characteristic of the Alstonville Plateau (Jenkins and Morand 2002), except for the unsuitable soil type observed at Uralba NR, where no burrows were found.

Small roots and rootlets around and on the burrow stage often appeared to be cleaned and appeared bright against the excavated soil. The remains of prey, mostly large millipedes, were also observed at the entrances to a number of burrows. Burrows were mostly absent from areas of deep leaf litter, particularly underneath Black Bean, *Castanospermum australe* (A. Cunn. ex Mudie) trees or where there was complete cover of leaf litter. Examples of the search tracks and burrow locations are shown in Figs 6-8. Table 2 contains a summary of the main management issues.

Discussion

Seven new populations of *N. atlas* were located, taking the number of known extant populations from four to 11. This represents a major improvement in the conservation outlook for this endangered species and it is likely that more populations will be found when other remnants on the Alstonville Plateau are surveyed in the future. Initially, future surveys should focus on the remaining unsurveyed mature Big Scrub remnants such as those identified by Parkes *et al*. (2008).

The data obtained for minimum burrow density highlight the patchiness of burrow distribution (Table 1). At Molly's Grass, burrows occurred across the whole remnant (Fig. 6), resulting in the highest density recorded of 302 burrows/ha. This contrasts with some of the other locations where burrows

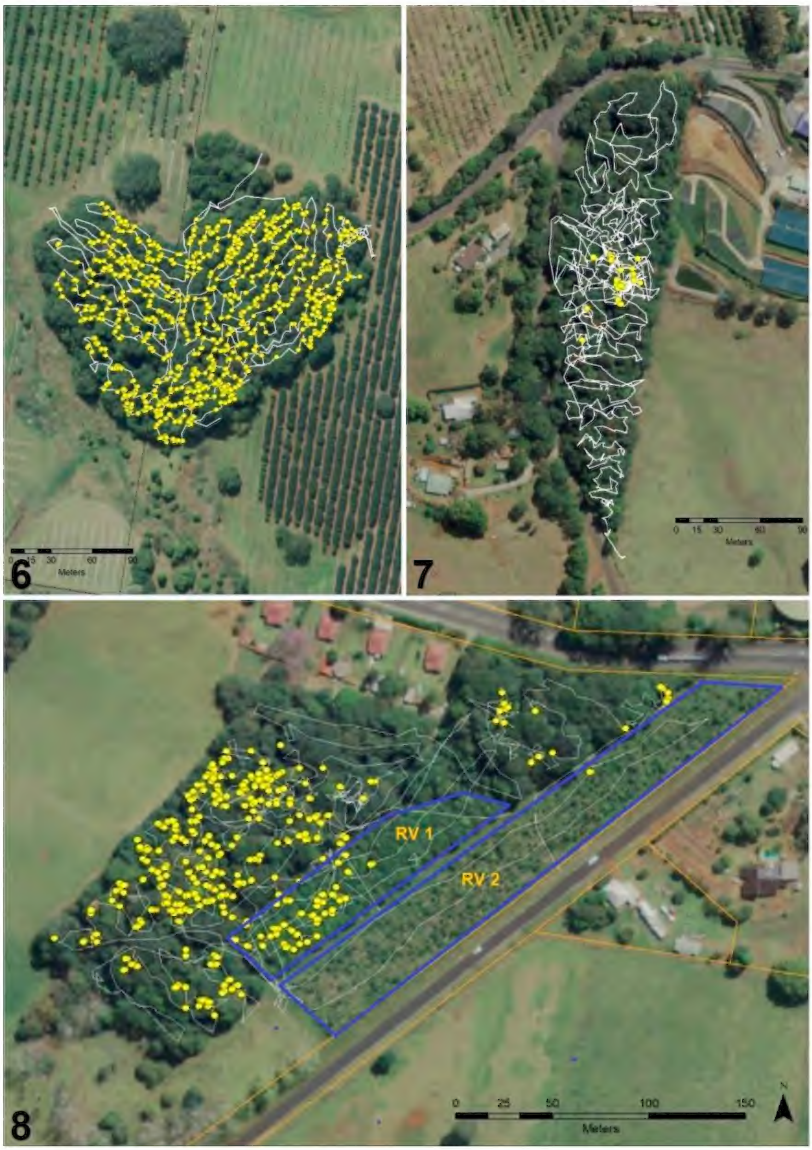
were clustered in a small section of the remnant, including at Willowbank (Fig 7) and Campbells Scrub, where there were densities of only 10 and 3 burrows/ha respectively.

Table 1. Results of the *N. atlas* burrow searches at each site. Numbers were very variable because of the patchy distribution of burrows. Minimum burrow density was calculated by dividing the number of burrows observed by the area surveyed. Estimates are considered a minimum number because not all of each location was exhaustively searched, particularly for the bottom eight sites. These data are mostly reproduced or derived from Charley (2018).

Site	Number of burrows	Dominant burrow site	Specimen collected	Area of rainforest patch (ha)	Approx. area surveyed (ha)	Minimum burrow density (burrows/ha)
Lumley Park, Alstonville	0			1.8	1.4	-
Willowbank	21	Roots/Rocks	Yes	1.9	1.9	10
Campbells Scrub	4	Roots		3.4	1.3	3
Whites Lane	85	Roots	Yes	1.4	1.1	77
Wollongbar Research Station	272	Roots	Yes	3.2	2.9	93
Dalwood Scrub	20	Roots		1.6	1.1	18
Brockley North	292	Roots	Yes	6.6	2.2	132
Brockley South	113	Roots		5.7	1.9	59
Molly's Grass	887	Roots/Rocks	Yes	3.4	2.9	302
Davis Scrub NR	45	Roots		14.4	0.2	260
Victoria Park NR	136	Roots/Rocks		15.5	2.8	48
Uralba NR	0			6.1	-	-
Dawes Scrub	0			6.1	0.4	-
Haynes Scrub	0			5.3	0.3	-
Andrew Johnston NR	0			33.5		-
Booyong Reserve	0			13.2		-
Killen Falls	0			3.3	0.8	-

Table 2. A summary of the observed management issues in the rainforest remnants examined by DC; for more detail see Charley (2018). Two additional sites (Andrew Johnston NR and Booyong Reserve) were searched unsuccessfully by G.B. Monteith in November 2017 and another (Killen Falls) by MA in September 2018.

Site	Condition	Management Issues
Lumley Park, Alstonville	Poor ground conditions.	Significant management issues: Australian Brush-turkey *Alectura lathami* (Gray, 1831), Cane Toads *Rhinella marina* (Linnaeus, 1758), Flying-foxes *Pteropus* spp, stormwater, collection.
Willowbank	Poor ground conditions.	Significant management issues: brush-turkeys, cane toads, weeds, stormwater, collection.
Campbells Scrub	Poor ground conditions.	Threatened by a large resident brush-turkey population, weeds, cane toads.
Whites Lane	Moderately good ground conditions.	Significant management issues: brush-turkeys, weeds, cattle, very small size, cane toads.
Wollongbar Research Station	High quality ground conditions, well managed.	Brush-turkeys, weeds, cane toads.
Dalwood Scrub	Moderate quality ground conditions.	Management issues associated with a flying=fox camp, brush-turkeys, weeds, cane toads.
Brockley North	High quality ground conditions.	Brush-turkeys, weeds, cane toads.
Brockley South	High quality, parts prone to flooding.	Riparian remnant, partly flood prone. Brush-turkeys, weeds, cane toads.
Molly's Grass	High quality ground conditions, well managed.	Brush-turkeys, weeds, cane toads.
Davis Scrub NR	High quality ground conditions, well managed.	Brush-turkeys, cane toads, collection. Weeds currently managed by bush regeneration project.
Victoria Park NR	High quality ground conditions, well managed.	Brush-turkeys, cane toads, visitor disturbance, collection. Weeds currently managed by bush regeneration project.
Uralba NR	Limited rainforest, unsuitable soil type (mostly sandy loam).	
Dawes Scrub	High quality ground conditions, well managed. Very rocky.	Cane toads, weeds.
Haynes Scrub	Moderate quality ground conditions, well managed. Rocky.	Brush-turkeys, cane toads. Weeds currently managed by bush regeneration project. Once highly fragmented and dominated by Camphor Laurel.
Andrew Johnston NR	High quality ground conditions, well managed.	Not assessed.
Booyong Reserve	High quality, well managed.	Not assessed. Prone to flooding.
Killen Falls	Steep and very rocky.	Not assessed.



Figs 6-8. Examples of survey effort and results from three sites. White lines indicate the survey track of the observer (DC) and yellow dots indicate the locations of *Nurus atlas* burrows: (6) Molly.s Grass; (7) Willowbank; (8) Wollongbar Research Station. Blue lines outline two revegetation areas of different ages; RV1 is older, planted around 1999, with canopy closed, while RV2, planted in 2007, is much younger with smaller, separated trees and extensive areas of grass cover.

Four of the new populations were relatively large, with more than 100 burrows in each. The largest populations were found in intact rainforest remnants at Molly's Grass, Brockley North and Wollongbar Research Station. The well-known sites in nature reserves (Victoria Park and Davis Scrub) are also likely to have large populations, based on exploratory surveys. These nature reserves were sampled only to confirm the continued presence of *N. atlas*. Significant burrow counts were recorded at both locations, suggesting the presence of large populations.

Preliminary searches of five northern sites (Dawes Scrub, Haynes Scrub, Booyong Reserve, Andrew Johnston NR and Killen Falls) did not locate populations of *N. atlas.* The soil surface at Dawes Scrub, Haynes Scrub and Killen Falls was very rocky and often steep. Haynes Scrub had been highly fragmented in the past and formerly contained numerous Camphor Laurel trees. Past disturbance may explain the absence of *N. atlas*. Booyong NR contains well developed rainforest but is on a regularly inundated flood terrace of the adjacent Wilson River and might not provide suitable habitat for *N. atlas*. The absence of the species from apparently suitable habitat in Andrew Johnston NR provides some indication that the Wilson River may form a northern barrier. This is supported by the presence of three other, more widespread species of *Nurus* (*N. latipennis* (Sloane, 1903), *N. moorei* Will & Monteith, 2018 and *N. perater* (Sloane, 1923)) north of the river in the foothills and slopes of the Nightcap Range (Will and Monteith 2018). However, further sampling is required to confirm whether the Wilson River does demarcate the distribution of the species.

The fragmented *N. atlas* populations existing now are likely to be extremely small relicts of an original, probably continuous population occupying the Big Scrub on the Alstonville Plateau. The Big Scrub was almost completely cleared by the late 1800s (Frith 1977), resulting in today's extremely fragmented landscape. Despite the 11 extant populations occurring within a radius of 10 km, there is unlikely to be much connectivity between them (an exception might be between Brockley North and South where there is about 1 km of disturbed but connecting forest). Generally, the matrix between the small habitat remnants consists of intensive agriculture, rural residential and urban land-uses that would be impassable for the flightless ground-beetles. Consequently, local extinctions are likely to be permanent as re-colonisation would appear to be unlikely, at least without intervention.

The smallest population (four burrows) at Campbells Scrub is probably a relict population that appears to be highly vulnerable to extinction. A large and active population of more than 42 Australian Brush-turkeys, *Alectura lathami* (Gray, 1831), is present within this remnant (DC, pers. obs.). Brush-turkey numbers have been relentlessly increasing across the NSW north coast in recent decades (DC and MA pers. obs.) and it is likely that the high numbers observed at Campbells Scrub are a relatively recent phenomenon.

Brush-turkeys were hunted for food and this is likely to be one of the reasons they were reduced to low numbers by early to mid last century (Jones and Everding 1991). The species was protected from hunting in the 1970s (*e.g.* they were listed in 1974 in the Queensland *Fauna Conservation Act 1974*; Jones and Everding 1991) and it is likely that this was the first time since human occupation of Australia that they were not subject to predation. Brush-turkeys have now become unafraid of people and highly proficient at exploiting human-dominated environments; their rapid increase in Brisbane since the 1970s (Jones and Everding 1991) and Sydney in recent decades is well documented in media reports (*e.g.* Taylor 2014, Hoh 2016, Brook 2017).

Elevated densities of brush-turkeys can cause environmental degradation such as significant declines in ground cover, leaf litter weight, seed density and seedling density (Warnken *et al*. 2004). Their impact on native fauna has not been well studied. The small Alstonville Plateau remnants are good breeding (mound building), roosting and foraging sites for brush-turkeys and animal predators of adult birds are scarce. Elevated numbers are likely to occur as the birds occupying the remnants obtain additional food from surrounding rural or urban areas, picnic areas, car parks, etc.

The litter layer and soil surface over much of the Campbells Scrub remnant is highly disturbed and frequently turned over by the foraging and nesting activity of the brush-turkeys. Prey items of *N. atlas* are likely to be reduced in number and the ground-beetles might not be able to maintain the integrity of their burrow entrances and hunting arenas. Urgent action might be required to save this population and it would be a good remnant in which to investigate brush-turkey control. This might be crucial as brush-turkeys can potentially become a threat at all sites.

The Cane Toad, *Rhinella marina* (Linnaeus, 1758), is another ubiquitous potential threat. Like brush-turkeys, cane toads are likely competitors for the prey of *N. atlas*. Furthermore, there are two critical periods when the ground-beetles are directly vulnerable to predation by toads: (i) when the adult male ground-beetles emerge on warm wet nights; and (ii) when they first hatch from the pupa and have not yet dug their first burrow. High numbers of cane toads could result in significant predation at these times as ground-beetles are known prey of cane toads (G.B. Monteith pers. comm.).

The presence of a large *Pteropus* spp flying-fox colony in the Dalwood remnant is fragmenting the forest canopy and opening the forest floor to increased wind and drying. Only a small number of *N. atlas* burrows (20) were found at this site and it is likely that this population is also highly threatened.

Stormwater discharge issues are evident in the Willowbank remnant where low numbers of burrows (21) were also recorded. The *N. atlas* population at this site is restricted to a small low ridge between two drainage lines and

overflow areas. The stormwater overflows from adjacent properties that could be affecting the population should be investigated and remedied.

At Lumley Park there were many burrows present in the 1970s (G.B. Monteith pers. obs.). After several unsuccessful surveys in recent years, it appears that this population might now be extinct. Recolonisation from the nearest extant population (Campbells Scrub) would require the ground-beetles traversing about 2 km of intensive agricultural and residential land along the disturbed riparian corridor of Maguires Creek. The presence of a large flying-fox camp, abundant Australian Brush-turkey nests (and signs of regular and extensive foraging activity), numerous stormwater drains directed into the reserve and the presence of the Cane Toad (DC, pers. obs.), could have contributed to the extinction of this isolated population.

Nurus atlas could be a useful species for indicating those forest remnants where the levels of historical disturbance have been less severe and ecological functioning has been retained to a greater degree than in those remnants where the species is absent. Similarly, where *N. atlas* is currently in decline, it could indicate remnants where contemporary threats are causing functional loss.

It was encouraging that several revegetation areas adjacent to extant *N. atlas* populations supported significant numbers, including at Victoria Park NR, Brockley North and Wollongbar Research Station (Fig. 8). Early stage plantings often have a deep and dense litter layer as there is insufficient canopy to create the moist microclimate that produces rapid decomposition. As the plantings age the canopy cover increases, the litter layer fragments, tree roots are exposed and log cover develops. *Nurus atlas* appears to be capable of occupying revegetation areas once the plantings are older than about 15-18 years. The presence of active burrows in these relatively young regenerating rainforest suggests that new populations could be artificially established in regenerating rainforest patches elsewhere on the Alstonville Plateau.

Conclusion

This study has greatly increased our understanding of *Nurus atlas* and almost trebled the number of known populations. It has also brought into focus the tenuous nature of the persistence of the species in small and isolated remnants where conservation of all the diverse rainforest-dependent species has been compressed into less than 2% of the landscape. Competition for scarce resources from native species such as brush-turkeys and flying-foxes is heightened by introduced species such as cane toads, creating a challenging ecosystem in which to survive. There appears to be one documented loss of a population from Lumley Park in Alstonville and although we think it likely that more populations will be found, there is currently no reason to be complacent about the future persistence of *N. atlas*.

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A NEW SPECIES OF THE GENUS *TACHYTA* KIRBY, 1837 FROM TORRES STRAIT, QUEENSLAND, AUSTRALIA (COLEOPTERA: CARABIDAE: BEMBIDIINI: TACHYINA)

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Abstract

A new species of the tachyine genus *Tachyta* Kirby, 1837 is described from two Torres Strait islands (Muralug and Ngurapai), off the north coast of Cape York Peninsula, northern Queensland, Australia: *Tachyta insularum* **sp. n**. The species belongs to the nominate subgenus. It is introduced into the most recent key to the Australian species of the genus *Tachyta*. *Tachyta brunnipennis* (Macleay, 1871) is recorded from the same two islands.

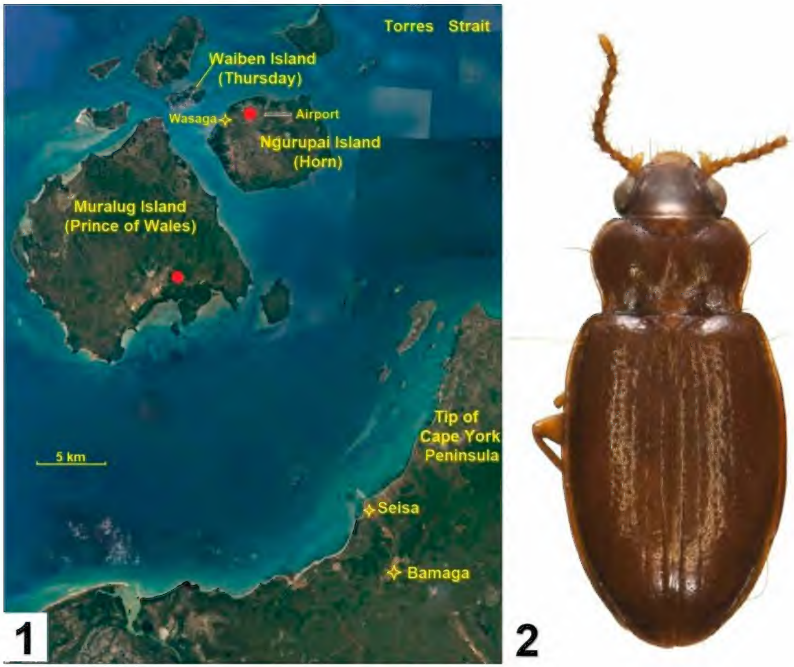
Introduction

Tachyta Kirby, 1837 is a genus of small tachyine carabid beetles that presently includes about 25 species. It occurs almost worldwide but is absent from the Neotropical Region, except for one species on the island of Haiti. Six species have been recorded from Australia: *T. brunnipennis* (Macleay, 1871), *T. ovata* Baehr, 1986, *T. rexensis* Moore, 2000, *T. palmerstoni* Baehr, 2006, *T. alutacea* Baehr, 2012 and *T. punctipennis* Baehr, 2012 (Erwin 1975, Baehr 1986, 2006, 2012, Moore *et al*. 1987, Moore 2000, Lorenz 2005). *Tachyta brunnipennis* is the most widespread, occurring from eastern Queensland through the northern parts of the Northern Territory to adjacent Western Australia north of the Great Sandy Desert, as well as in southeastern New Guinea. *Tachyta ovata* is recorded from tropical Northern Territory and the adjacent extreme north of Western Australia and is sympatric throughout its range with *T. brunnipennis. Tachyta rexensis*, *T. palmerstoni*, *T. alutacea* and *T. punctipennis* occur only in northeastern Queensland. *Tachyta brunnipennis*, *T. ovata* and *T. alutacea* live under bark of trees in open forest and woodland, while *T. rexensis* and *T. palmerstoni* have been collected from the bark of trees in montane rain forest. *Tachyta punctipennis* has been taken from *Pandanus* trees in open forest. *Tachyta brunnipennis* and *T. ovata* are sometimes found in large numbers in suitable environments, whereas *T. rexensis*, *T. palmerstoni*, *T. alutacea* and *T. punctipennis* are known from single or very few specimens.

Erwin (1975) divided *Tachyta* into two subgenera: *Tachyta* s. str. includes depressed species with more or less distinct microreticulation always present on the whole dorsal surface, while the subgenus *Paratachyta* Erwin, 1975 has very glossy species that lack microreticulation except on the labrum. *Paratachyta* is confined to the Oriental Region and the Papuan Subregion and is not yet recorded from Australia, whereas subgenus *Tachyta* is distributed throughout the whole range of the genus. Recently, Baehr (2012, 2016) erected two additional subgenera for quite aberrant species: *Australotachyta* Baehr, 2012 for a species from northern Australia (*T. punctipennis* Baehr,

2012) and *Eurytachyta* Baehr, 2016 for a species from Borneo (*T. laticollis* Baehr, 2016).

Among Australian Carabidae sent from the Queensland Museum, Brisbane for identification were two specimens of *Tachyta* that clearly differ from all species so far recorded from Australia, New Guinea or the Oriental Region. They were collected on two adjacent islands, Ngurupai (formerly Horn Island) and Muralug (formerly Prince of Wales Island), just off the northern tip of Cape York Peninsula, northern Queensland (Fig. 1), and are described as a new species below.



Figs 1-2. *Tachyta* (s. str.) *insularum* **sp. n.**: (1) Map of southern Torres Strait showing collection sites of the two type specimens as red spots; (2) dorsal view of holotype, body length 2.2 mm.

Methods

Genitalia were removed and relaxed overnight in a jar under moist atmosphere, then cleaned for a short while in hot 10% KOH. The digital habitus photograph was taken using ProgRes CapturePro 2.6 and AutoMontage and was edited with Corel Photo Paint X4. Measurements were taken with an ocular micrometer in a stereo microscope. Overall length was measured from apex of the labrum to apex of the elytra. Pronotal length was

taken along midline. Elytral length was taken from the most advanced part of the humerus to the most advanced part of the apex.

The holotype is in the Queensland Museum, Brisbane (QMB) and the paratype is in the working collection of the author in the Zoologische Staatssammlung, München (CBM). Data of examined material are given in full as on the labels, including all ciphers. Original collecting date spelling is used.

Subgenus *Tachyta* s. str.

Kirby. 1837: 56. – Erwin 1975: 5.

Type species. *Tachyta picipes* Kirby, 1837 (= *Tachyta nana inornata* (Say, 1823)).

Diagnosis. As in all species of *Tachyta* with a straight, elongate recurrent stria on the elytra that runs close to the lateral margin and with finely denticulate tarsal claws. The subgenus includes depressed species with complete, although more or less strongly impressed, microreticulation on the whole dorsal surface.

Tachyta insularum sp. n.

(Figs 2-3)

Material examined. Holotype ♀, 'Qld: 10°36.6'S x 142°16.0'E Horn Is., 2.5 km E Wasaga, 8.Jan2008, sandy heath. G. Monteith, K. Aland. 15489 pyrethrum, tree trunks. 10 m.' (QMT234159). *Paratype*: 1 ♀, 'Qld: 10°42.3'Sx142°13.5'E Prince of Wales Is., camp 3-7.Jan2008, 15460 G. Monteith, K. Aland. 10 m.' (CBM).

Diagnosis. Distinguished from the other Australian species of the nominate subgenus by very superficial or even almost invisible microreticulation of the pronotum, in combination with moderately dense microreticulation of the elytra but extremely distinct and coarse punctures on intervals; further distinguished from *T. ovata* Baehr and *T. rexensis* Moore by narrower pronotum and longer and narrower elytra.

Description. Measurements. Length: 2.2 mm; width: 0.96-0.98 mm. Ratios: width/length of pronotum: 1.66-1.70; widest diameter/width of base of pronotum: 1.16-1.17; length/width of elytra: 1.54-1.56.

Colour (Fig. 2). Unicolourous reddish brown, antenna rufous, palpi dirty yellow, legs pale rufous.

Head (Fig. 2). Across eyes about as wide as pronotum at apical angles. Eye large, laterad well produced, orbit short. Lower surface of eye and orbit with a few very short hairs. Frons near eye with a slightly sinuate, oblique ridge, the anterior supraorbital seta situated in a large and deep groove. Antenna short, barely surpassing base of pronotum, median antennomeres about as long as wide. Surface with distinct and coarse, isodiametric to slightly transverse microreticulation, frons and posterior part of clypeus with scattered, rather coarse punctures.

Pronotum (Fig. 2). Comparatively narrow, much narrower than the elytra, rather cordiform, widest at anterior two-fifths, dorsal surface moderately convex. Apex very gently sinuate, apical angles slightly protruded but rounded. Lateral margin in anterior half moderately convex, in basal half gently oblique and slightly concave. Basal angles acute, less than 90°, slightly produced laterad and posteriad. Base in middle slightly produced. Apex not bordered, lateral margin with very narrow lateral sulcus, base only laterally bordered. Anterior marginal seta situated at widest diameter, posterior seta located at basal angle. Median line deeply impressed but incomplete, running from the anterior to the posterior transverse sulcus. Anterior sulcus very shallow, indistinct, posterior sulcus deeply impressed, oblique. Disc with coarse, very distinct, isodiametric microreticulation that becomes slightly more transverse towards the lateral margin. Punctures scattered, coarse but difficult to detect within the coarse microreticulation.

Elytra (Fig. 2). Comparatively elongate, distinctly oviform, widest slightly behind middle, on disc depressed. Only two median striae very slightly impressed, punctate, other striae distinctly punctate but not impressed, even the 7th stria in middle quite recognizable. Anterior discal pore and seta situated immediately inside of the 4th stria and close to the base, clearly in front of the 4th marginal pore and seta. Posterior discal seta likewise situated near the 4th stria, at apical fourth of the elytra. Recurrent stria elongate. Surface with coarse, very distinct, alutaceous microreticulation, very dull. Intervals depressed, with an irregular series of sparse, fairly coarse punctures that are very difficult to detect within the coarse, dense microreticulation. Marginal setae, when present, very elongate.

Lower surface. Thoracic sterna and abdomen with fine, very short, erect pilosity that is slightly denser on the prosternum and on the terminal abdominal sternum. The latter in the female quadrisetose. Metepisternum elongate, about 1.75 times as long as wide at apex.

Male genitalia. Unknown.

Female gonocoxites (Fig. 3). Gonocoxite 1 narrow and elongate, without setae at apical margin. Gonocoxite 2 elongate, moderately curved, acute at apex; with two large and elongate ensiform setae situated close together in the middle of the ventrolateral margin, the lower seta being slightly larger than the upper seta; without any ensiform seta in middle of dorsomedian margin; with two very elongate nematiform setae at the apical third of median rim.

Variation. Little variation noted in degree of microreticulation of pronotum.

Etymology. The name refers to the occurrence on the Torres Strait Islands.

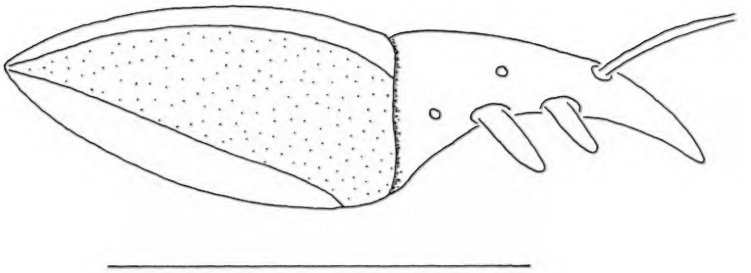


Fig. 3. *Tachyta* (s. str.) *insularum* sp. n.: female gonocoxites. Scale bar: 0.1 mm.

Distribution (Fig. 1). Ngurapai (Horn) Island and Muralug (Prince of Wales) Island, which are mainland formation islands in Torres Strait separated by a narrow strait 1.7 km wide. They both lie about 17 km off the northern tip of Cape York Peninsula in northern Queensland.

Collecting circumstances. The holotype was collected by pyrethrum fogging on tree trunks in sandy heath. On both islands a specimen of *T. brunnipennis* was taken at the same localities, which means that the two species are sympatric and perhaps even syntopic.

Remarks. The biology of the new species is barely recorded. The holotype was collected 'in sandy heath' by pyrethrum spraying of tree trunks. No collecting circumstances are recorded for the paratype except that it was taken at the campsite, which was in grassy eucalypt forest (G. Monteith pers. comm.). Hence, the species seems to occur on and under bark of trees, much like *Tachyta brunnipennis*, which was collected at the same localities using the same sampling methods.

In its morphological characters, *T. insularum* is intermediate between *T. brunnipennis* and *T. palmerstoni* but more similar to *T. brunnipennis*. There is a gradient in gradually decreasing development of the microreticulation of the surface from *T. alutacea* → *T. brunnipennis* → *T. insularum* → *T. palmerstoni*. The first three species most probably live on tree trunks in open forest and woodland but *T. palmerstoni* is a rainforest dwelling species. It may be speculated that a strongly microreticulate surface is advantageous for open country inhabiting species, for whatever reasons, while a rather glossy surface is beneficial for rainforest species. Indeed, many species living in rainforest possess a glossy surface. The reasons for these different adaptations are speculative but in some way they might act as protection against enemies.

Discussion

The new species was collected on islands north of Cape York Peninsula that connect northernmost Queensland with the southeastern part of New Guinea. This area is well known for the large number of northern species unique in Australia, some of which have invaded northern Queensland from New Guinea more or less recently, perhaps using the Torres Strait islands as stepping stones. In the genus *Tachyta*, however, a reverse migration seems to have occurred. Not only has *T. brunnipennis* been recorded in the southeastern part of New Guinea, which in its vegetation and environment is very similar to Cape York Peninsula in northern Queensland, but apparently no species of Oriental origin (*e.g. T. umbrosa* Motschulsky, 1851), nor any species of the subgenus *Paratachyta* Erwin, 1972, have succeeded in dispersing to northern Australia.

Revised key to Australian species of genus *Tachyta* Kirby

1 Dorsal surface with distinct, although in some species rather superficial microreticulation; elytra depressed with far less coarsely punctate striae but with punctate intervals. Subgenus *Tachyta* s. str. 2

– Dorsal surface without microreticulation; elytra moderately convex with very coarsely punctate striae and impunctate intervals. Subgenus *Australotachyta* Baehr ..... *punctipennis* Baehr, 2012

2 Elongate species, ratio length/width of elytra > 1.45 3

– Wider and shorter species, ratio length/width of elytra < 1.35 6

3 Surface of elytra with distinct to very coarse microreticulation, more or less dull; elytral intervals either with coarse punctures or without any visible punctures; pronotum laterally more convex and with deeper lateral sinuation 4

– Surface of elytra with superficial microreticulation, rather glossy; intervals with fine and sparse punctures; pronotum laterally less convex and with faint lateral sinuation. Atherton Tableland, NE Queensland ..... *palmerstoni* Baehr, 2006

4 Punctures of the elytral intervals distinct and easily visible; microreticulation less coarse; pronotum wider, ratio width/length > 1.58, with wider base; elytra shorter and rather parallel-sided, ratio length/width < 1.56 5

– Punctures of the elytral intervals indistinct and barely visible; microreticulation of pronotum and elytra very coarse, markedly alutaceous; pronotum narrower, ratio width/length < 1.50, with narrower base; elytra longer and distinctly oviform, ratio length/width 1.6. Lower Cape York Peninsula, NE Queensland .... *alutacea* Baehr, 2012

5 Microreticulation of pronotum distinct and coarse, that of elytra coarse, therefore punctures of intervals less distinct; elytra shorter and rather parallel-sided, ratio length/width < 1.5; commonly head and pronotum considerably paler than the elytra. Eastern Queensland, northern part of Northern Territory, Western Australia north of Great Sandy Desert; southern Torres Strait islands and southern New Guinea ....*brunnipennis* (Macleay, 1871)

– Microreticulation of pronotum superficial or almost invisible, that of elytra less coarse, therefore punctures of intervals very distinct; elytra slightly longer and less parallel-sided, ratio length/width > 1.54; colour uniformly reddish piceous. Southern islands of Torres Strait, northern Queensland ..... *insularum* **sp. n.**

6 Surface with distinct microreticulation, moderately dull; antenna shorter, median antennomeres as long as wide. Northern part of Northern Territory and adjacent northern Western Australia .... *ovata* Baehr, 1986

– Surface with superficial microreticulation, rather glossy; antenna longer, median antennomeres clearly longer than wide. NE Queensland ..... *rexensis* Moore, 2000

Acknowledgements

My sincere thanks are due to Christine Lambkin, Susan Wright and Geoff Monteith of Queensland Museum, Brisbane, for the kind loan of the specimens. Geoff Monteith kindly prepared the map and thanks the Kaurareg people, traditional owners of the islands, for permission to make collections on their land in 2008.

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A NEW SPECIES OF *TREPHISA* MOORE (COLEOPTERA: CARABIDAE: MORIOMORPHINI) FROM THE BRINDABELLA RANGE, AUSTRALIAN CAPITAL TERRITORY

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Abstract

Trephisa barrymoorei **sp. n.** is described from near the summit of Mt Gingera, Australian Capital Territory. This second species of *Trephisa* Moore shares numerous synapomorphies with the type species, *T. parallela* Moore, establishing cladistic criteria for recognizing *Trephisa* as a monophyletic taxon. The two species of *Trephisa* share other synapomorphies with species of *Teraphis* Castelnau, 1867 and these two genera are proposed as sister taxa. The two species of *Trephisa* are known only from high elevation sites: *T. parallela* from closed canopy *Nothofagus* forests on the Lamington and Springbrook Plateaux, Queensland and *T. barrymoorei* from snow gum (*Eucalyptus pauciflora* Sieber) forest on Mt Gingera in the Brindabella Range, A.C.T.

Introduction

Moore (1963), in his revision of the Australian Psydrinae, provided the first comprehensive treatment of genera now recognized as members of the tribe Moriomorphini (Sloane 1890, Liebherr 2011). Moore's (1963) treatment included descriptions of four new genera: 1, *Trephisa* Moore; 2, *Sitaphe* Moore; 3, *Theprisa* Moore; and 4, *Neonomius* Moore. All remain valid today. The first of these, *Trephisa*, was most precisely diagnosed by Moore (1963) based on reduced eyes, elongate labial paraglossae, submoniliform antennae and dorsally setose tarsomeres, although other more broadly distributed characters such as fully striate elytra and a carinate eighth elytral interval were also presented. Moore himself (1977) subsequently suggested that the microphthalmic condition of the cave-adapted *Teraphis cavicola* Moore, 1977 eliminated one of the diagnostic characters he used in 1963 to distinguish *Trephisa* from *Teraphis* Castelnau, 1867. He maintained *Trephisa* as distinct based on 'its narrow, subcylindrical build and also its minutely crenulate subhumeral (elytral) margins (Moore 1977: 94)', noting that a more thorough knowledge of the Australian fauna was required before arriving at any definitive conclusion. This contribution offers a new species of *Trephisa* that allows us to build on Moore's (1963) diagnosis of the genus and thereby to affirm Moore's recognition of *Trephisa* as a distinct lineage worthy of generic-level recognition.

Materials and methods

Specimens revised in this contribution were provided by the Museum of Comparative Zoology, Harvard University (MCZ: Philip D. Perkins curator) and the Queensland Museum (QMB: Susan Wright, collection manager). The holotype for the new species is deposited in the Australian National Insect Collection (ANIC: Cate Lemann curator) and a DNA-sequence voucher specimen of *T. parallela* is deposited in the Oregon State Arthropod

Collection (OSAC: David Maddison director). Specimens compared with the *Trephisa* specimens treated below were borrowed from the Field Museum of Natural History, Chicago (Al Newton and Margaret Thayer curators) and the Zoological Museum, University of Copenhagen (Alexey Solidovnikov curator). Specimen preparation protocols are identical to those described in Liebherr (2015), with the exception that the female reproductive tracts and their associated abdomens from specimens collected by P.J. Darlington, Jr., were cleared in cold 10% KOH for three days, not one as is usual for most specimens. The female reproductive tracts were then dissected from the abdomens, neutralised in weak acetic acid, stained using Chlorazol Black® in methyl cellosolve and slide mounted in glycerine for viewing. Several mensural and ratio-based attributes are used to describe the beetles. These include standardised body length, *i.e.* the sum of three measurements: the length of the head measured from anterior labral margin to cervical ridge adjacent to the pronotum, pronotal length measured along the midline and elytral length measured from the base of the elevated scutellar surface to the apex of the longer elytron. Ratio-based descriptors include: 1, ocular ratio, *i.e.* head width across outer surfaces of the eyes divided by the minimum frons width between the eyes; 2, ocular lobe ratio, or the length of the eye measured from above divided by the length of the ocular lobe from the front margin of the eye to the angled juncture with the gena; 3, mandibular length ratio, or the distance from the left mandibular apex to anterior (dorsal) condyle divided by the distance from the anterolateral margin of the labrum to that same condyle; 4, relative pronotal width, or maximum pronotal width divided by pronotal length along the midline; 5, relative pronotal basal constriction, or maximum pronotal width divided by pronotal width across its hind angles. Male genitalic characters are described based on terminology presented in Liebherr (2018) and female reproductive tract characters follow the terminology established in Ball and Shpeley (1983) and Liebherr and Will (1998). The number of specimens measured for external characters or assessed for genitalic characters is provided at the beginning of appropriate sections of the descriptions. Label data are transcribed verbatim, with different lines of text separated by a slash '/', and different labels separated by a double slash '//'. A photocopy of P.J. Darlington, Jr.'s 50 pp typescript 1956-1958 field diary for Australia, provided by P.D. Perkins to G.B. Monteith, Queensland Museum, is the source for Darlington's collecting information on *T. parallela*.

***Trephisa* Moore, 1963**

Trephisa Moore 1963: 282 (type species *Trephisa parallela* Moore, by original designation).

Diagnosis. Beetles of subparallel body form, with only moderately convex elytra, the elytral disc flat medially (Figs 1-2); eyes very small to moderately sized, with ocular lobe little projected from head, its hind margin at very

obtuse angle with gena and with lobe-genal juncture without groove; labial paraglossae elongate, narrow, porrect, extended as far beyond truncate, well-sclerotised anterior margin of ligula as distance from paraglossal base to ligular margin; pronotal laterobasal depression broad, consisting of medial longitudinal depression bordered laterally by a broad tubercle; a single dorsal elytral seta in the third elytral interval (unilaterally two setae or no setae can be present), the depression surrounding the dorsal seta very shallow and extended over only 1/4 of the interval breadth; basal elytral groove slightly undulated at the bases of the striae; mesepisternum punctate, with ~10 punctures in 2-3 dorsoventral rows covering its surface; suture between metepisternum and metepimeron reduced, obsolete, the surface between the sclerites nearly smooth; tarsomeres with a sparse covering of elongate setae, best represented on tarsomeres 4-5; elytral disc with regular, well developed transverse mesh microsculpture, the sculpticells 2-3 × broad as long.

Key to adults of the species of *Trephisa* Moore

1 Larger, more piceous beetles (Fig. 1), standardized body length 6.1-6.5 mm; eyes small, ocular ratio 1.25-1.27, ocular lobe ratio 0.56-0.68, 12-15 ommatidia present across horizontal diameter of eye; frontal grooves broad, deep, their surface laterad convex; frons irregularly punctate; elytral lateral margin smoothly convex posterad angulate, toothed humerus; ventral body surface uniformly dark, piceous except for contrastingly paler dark rufous tibiae ..... *Trephisa barrymoorei* **sp. n.**

– Smaller, more rufous beetles (Fig. 2), standardized body length 4.8-5.6 mm; eyes very small, ocular ratio 1.06-1.12, ocular lobe ratio 0.31-0.41, 4-5 ommatidia present across horizontal diameter of eye; frontal grooves smooth, arcuately convergent, frons medially with 7-9 transverse strigae; elytral lateral margin distinctly crenulate posterad angulate, toothed humerus; ventral body surface dark brunneous, prothoracic and elytral epipleura rufobrunneous, legs entirely brunneous .... *Trephisa parallela* Moore

Trephisa barrymoorei sp. n.

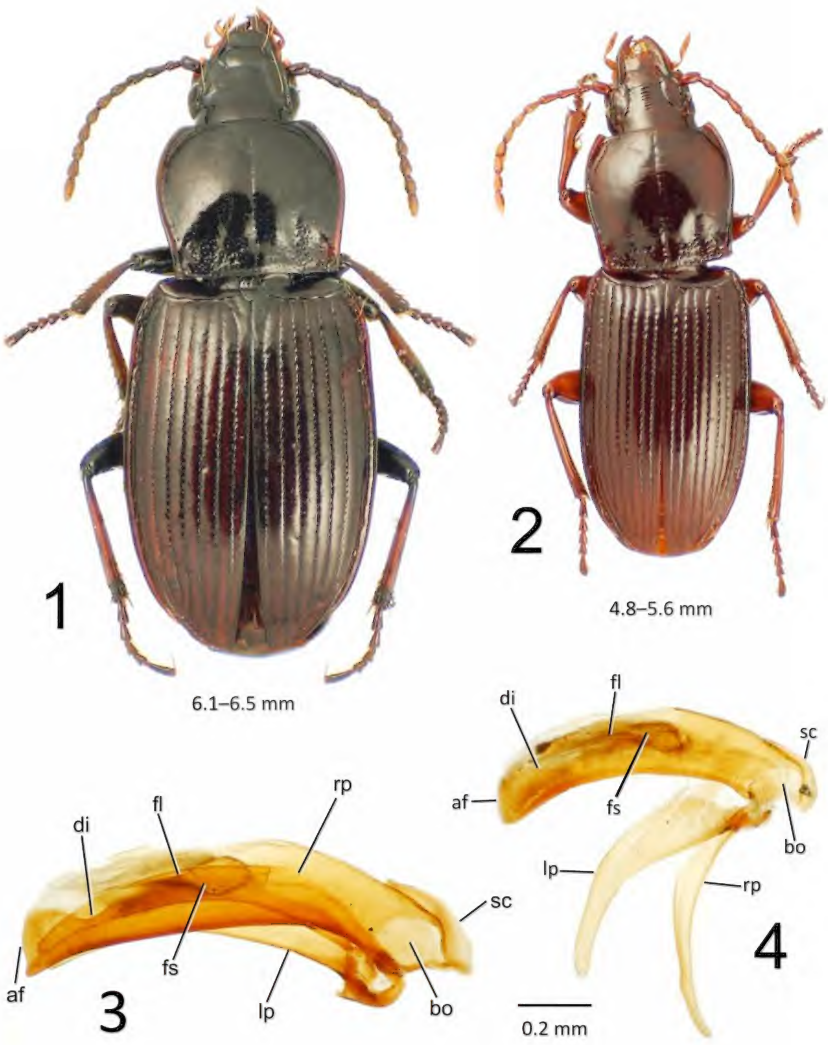
(Figs 1, 3, 5-8)

Type material. Holotype ♂ (dissected with male genitalia in polyethylene genitalia vial on pin), Brindabella / Rge to Mt. / Gingera ACT / 6000' May '57 // Phersita # 2 (handwritten) // HOLOTYPE / Trephisa / barrymoorei / J.K. Liebherr 2018 (black-margined red label) (MCZ specimen deposited in ANIC). *Paratypic allotype* ♀ (dissected with abdominal ventrites on mounting card and reproductive tract in genitalia vial on pin), same date-locality data (MCZ). *Paratype* ♂, same date-locality data (MCZ). The allotype and paratype bear an additional label beneath the date-locality label: Australia / Dec56 - Jun 58 / Darlingtons.

Diagnosis. In addition to the diagnostic features in the key couplet, this species exhibits a shallow transverse impression on the vertex between the hind margins of the eyes. There are either one or two dorsal elytral setae,

with the obvious anterior seta immediately mesad the third elytral striae situated before elytral midlength, whereas the anterior dorsal elytral seta of *T. parallela* individuals is placed at or posterad elytral midlength. The eighth elytral interval is distinctly carinate dorsad the well developed subapical sinuation in this species, whereas this interval is more broadly rounded, although equally upraised, dorsad the shallow subapical sinuation of *T. parallela*. Also, the strial punctures are slightly larger in this species and the elytral lateral marginal depression is broader, more explanate in this species, especially evident immediately posterad the humerus.

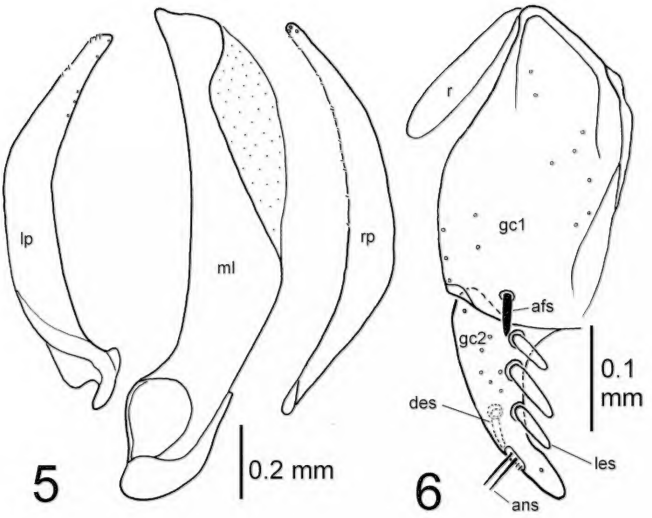
Description (n = 3). Head broad with small eyes, gena visibly surrounding eyes in dorsal view; two supraorbital setae each side; antennae robust, basal 3 antennomeres glabrous except for single apical setae on scape and pedicel, and apical ring of setae on antennomere 3, apical half of antennomere 4 and antennomeres 5-11 covered with fine pelage of setae; apical antennomeres submoniliform, length of antennomere 9 1.2 × maximal breadth; labrum slightly emarginate apically; mandible moderately elongate, mandibular length ratio 1.8; maxillary palpomeres glabrous, apical palpomere fusiform; maxillary lacinia with hook-like apex; labial palpomeres gracile, basal palpomere narrow, bisetose; mentum tooth broadly rounded, mentum lateral lobes broadly, convexly rounded to narrowly rounded apices and mentum surface moderately depressed at mental setae; submentum longitudinally impressed each side of midline, two setae each side. Pronotum broadly subquadrate, lateral margins slightly sinuate before nearly right hind angles; two pronotal setae each side, lateral seta about 1/3 pronotal length from front angle, basal seta inside lateral and basal beads, equidistant from both margins; basal margin slightly undulated, a fine marginal bead present across base; median base moderately depressed relative to disc, convex medially, surface punctate laterally, with about 20 small punctures between midline and longitudinal impression on inner portion of laterobasal depression; outer portion of laterobasal depression slightly elevated in a low tubercle, the surface evenly punctate to the broad lateral convexity adjacent to the broad lateral marginal bead; median longitudinal impression continuous, irregularly punctate along its length, the punctures joined by fine shallow impressions; anterior transverse impression broad, shallow, evident only near middle of disc; anterior margin beaded in outer 2/3 of breadth each side, the bead absent medially; front angles protruded and depressed relative to disc, apex of angles narrowly rounded; lateral marginal depression narrow just behind front angle but microsculpture still evident in the deepest portion, marginal depression broadened from lateral seta to oblique convexity inside hind angle; prosternum smooth, slightly depressed between procoxae, convex anteriorly, smooth laterally without any anteapical groove; proepisternum mostly smooth, variably with 10-17 very shallow and indistinct punctures distributed on proepisternum from near procoxal cavity dorsad along margin with proepimeron; proepimeron smooth, suture before meron impunctate.



Figs 1-4. *Trephisa* spp: (1) *T. barrymoorei* **sp. n.** holotype, dorsal view; (2) *T. parallela* male paratype (MCZ), dorsal view; (3) *T. barrymoorei* holotype male aedeagus, right view; (4) *T. parallela* paratype male aedeagus, right view. Scale bar for Figs 3-4 only. Abbreviations: af, apical face of median lobe; bo, basal opening of median lobe; di, dorsal invagination of ostial opening sclerotized margin, right side; fl, flagellum of internal sac; fs, flagellar sheath of internal sac; lp, left paramere; rp, right paramere; sc, sagittal crest of median lobe.

Elytra subquadrate, humeri broad; parascutellar seta present, very short; parascutellar striole short, comprising 2-3 connected punctures and broadly joining basal elytral groove at parascutellar seta; basal elytral groove moderately recurved to acutely angulate humerus, the groove undulated due to basal expansions of striae 1-5; a humeral tooth present at juncture of basal elytral groove and lateral elytral margin; 1-2 dorsal elytral setae, with each mesad third interval – actual counts for dorsal elytral setae for three type specimens, left + right elytron, are: 2 + 1, 1 + 1, 1 + 0; striae 1-8 all complete, punctate, the punctures slightly expanding strial breadth; interval 8 subcarinate apically; subapical and apical setae present in stria 7; lateral elytral setae arranged in anterior series of 7 setae, posterior series of 6. Metathoracic flight wings vestigial, the rudiment a broad subtriangular flap that does not extend beyond posterior margin of metanotum, flap with subcostal+radial and medial vein thickenings (viewed under elytron of dissected female specimen); metepisternum maximum width subequal to lateral length. Abdomen with ventrites 1-4 visibly punctate laterally, ventrite 4 with only 3 punctures; suture between visible ventrites 1 and 2 sinuous laterally, the surface of ventrite 2 inside the sinuosity depressed; sutures between ventrites 3-6 deep, broad, lined with distinct punctures; apical ventrite of male with 3 setae each side, all 6 setae equidistant from beaded margin and nearly equidistant neighbour to neighbour; apical ventrite of female also with 3 setae each side but with the 2 sets of 3 setae more separated along midline than each to the next on each side. Legs robust; profemur with 2 posterior setae; mesocoxa bisetose, a ventral seta and 1 seta on coxal ridge; mesofemur bisetose anteroventrally; metacoxa bisetose, 2 lateral setae present; metafemur bisetose anteroventrally; mesotibiae straight, apex broadly expanded; tarsomeres setose dorsally, in addition to apical and subapical setae, several elongate setae sparsely distributed over dorsum of tarsomeres 4 and 5. Microsculpture of frons indistinct, transverse mesh or lines visible over portions of surface; pronotal disc covered with a transverse mesh, sculpticell breadth 3-4 × length; pronotal base with evident transverse mesh, sculpticell breadth 2-3 × length; as also for *T. parallela*, the elytral disc is covered with a regular transverse mesh, sculpticell breadth 2-3 × length; abdominal ventrites with swirling isodiametric and transverse sculpticells.

Male genitalia (n = 1) (Figs 3, 5). Aedeagus gracile, evenly curved dorsally, with well developed basal sagittal crest, a basal opening on the right-hand side of median lobe that services sperm tube and a dorsal invagination along sclerotised margin of ostial opening; median lobe apex broadly rounded with short, nipple-like tip ventrally on apical face; internal sac bearing an elongate, acute flagellum and associated flagellar sheath; right paramere narrow, elongate, with ventral surface lined with very short setae and glabrous apex bearing several sensilla; left paramere more robust, its basal articulation resulting in a twisted lateral margin, with several sensilla and very short setae (sensilla basiconica) along margins near apex.



Figs 5-6. *Trephisa barrymoorei*, sp. n.: (5) male aedeagus, with median lobe in right-lateral view and parameres in ectal views; (6) female left gonocoxa, ventral view. Abbreviations: lp, left paramere; ml, median lobe; rp, right paramere; afs, apical fringe seta; ans, apical nematiform setae; des, dorsal ensiform seta; gc1, basal gonocoxite; gc2, apical gonocoxite; les, lateral ensiform setae.

Female reproductive tract (n = 1) (Figs 6-7). Gonocoxa bipartite, basal gonocoxite 1 with a single apical fringe seta (Fig. 6) and scattered sensilla; ramus present as a membranous fold; apical gonocoxite 2 moderately narrow basally, 2-3 lateral ensiform setae along lateral margin of gonocoxite, the setae less than 0.4 × length of gonocoxite; 1 dorsal ensiform seta not visible in ventral view; 2 apical nematiform setae in sensory fossa set within 0.25 × length from gonocoxite apex; bursa copulatrix broad, columnar, about twice as long as broad (Fig. 7); spermathecal duct joining bursa ventrally near juncture with common oviduct; a broadly rounded helminthoid sclerite present at juncture of spermathecal duct and bursa; spermathecal duct of similar diameter to spermathecal reservoir, the latter distinguishable by helicoid 'taenidia-like' cuticular ridges; spermathecal gland present, appended at base of spermathecal reservoir.

Etymology. The compound species epithet, *barrymoorei*, honours Dr Barry P. Moore's scientific legacy that spanned the fields of chemistry, chemical ecology and insect systematics.

Distribution and habitat. Based on the label data, the type series of this species from 6000' elevation would have been collected in the vicinity of the 6050 ft (1845 m) summit of Mt Gingera (Fig. 8). Notes from P.J. Darlington's collecting diary for that period state 'we made several trips to

the Brindabella Ranges during May, and the snow held off and the weather actually improved so much that on June 1 we reached Mt. Gingera ... and did some effective collecting there, although the ground was abnormally dry. The altitude is about 6000' and the high country is mostly covered with snow gum woods and some open areas (G. Monteith pers. comm.).' Darlington's access to Mt Gingera would have been via the road running west from Canberra that then approximately follows the State border between A.C.T. and New South Wales south along the crest of the Brindabella Range to Mt Gingera, situated directly on the border. Darlington nominated A.C.T. as the site of collection on his date-locality label.

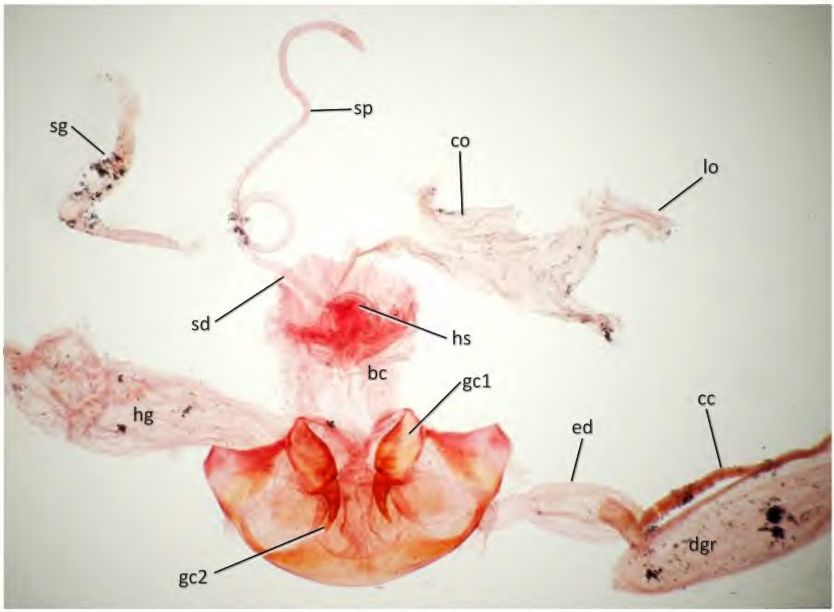


Fig. 7. Cleared and stained female reproductive tract of *Trephisa barrymoorei*, **sp. n**. paratypic allotype, ventral view. Abbreviations: bc, bursa copulatrix; cc, collecting canal of pygidial defensive gland; co, common oviduct; dgr, defensive gland reservoir; ed, efferent duct of defensive gland; gc1, basal gonocoxite; gc2, apical gonocoxite; hg, hindgut; hs, helminthoid sclerite; lo, lateral oviduct; sd, spermathecal duct; sg, spermathecal gland; sp, spermatheca.

***Trephisa parallela* Moore**

(Figs 2, 4, 8)

Trephisa parallela Moore 1963: 282.

Type material. Holotype ♂ and paratype (immature) ♀ (ANIC), 'V. BinnaBurra / M' PhersonRge / May58, Q-NSW / 2600-3600' / Darlingtons.' Two paratypes, ♂ and ♀ with same data (MCZ).

Additional material. Two specimens, ♂ and immature ♀ with same label data as types (MCZ). Female specimen (QMB): 28°14′27.4″S/153°15′56.0″E / AUSTRALIA: Queensland / Springbrook National Park / nr. repeater tower, 1002 m / 28.xi.2010 // K.Will & G.B. Monteith / [AUS2010.xi.28.1]. Disarticulated female specimen used for DNA sequencing (QMB deposited in OSAC): Springbrook 14.3.97 / *Trephisa parallela* // DNA 1080.

Diagnosis. For external characters, see identification key and the diagnosis of *T. barrymoorei*. The male aedeagus differs from that of *T. barrymoorei* in the broadly rounded apex with evenly convex apical face and the less pronounced sagittal crest (Fig. 4). Some variability in these characters exists, as Moore's (1963; fig. 8) rendition of the holotypic *T. parallela* aedeagus presented a slight apical extension, not the broadly rounded apex as observed in the MCZ paratype (Fig. 4). Nonetheless, neither specimen has a tip as narrowly rounded as that of the *T. barrymoorei* holotype (Fig. 3).

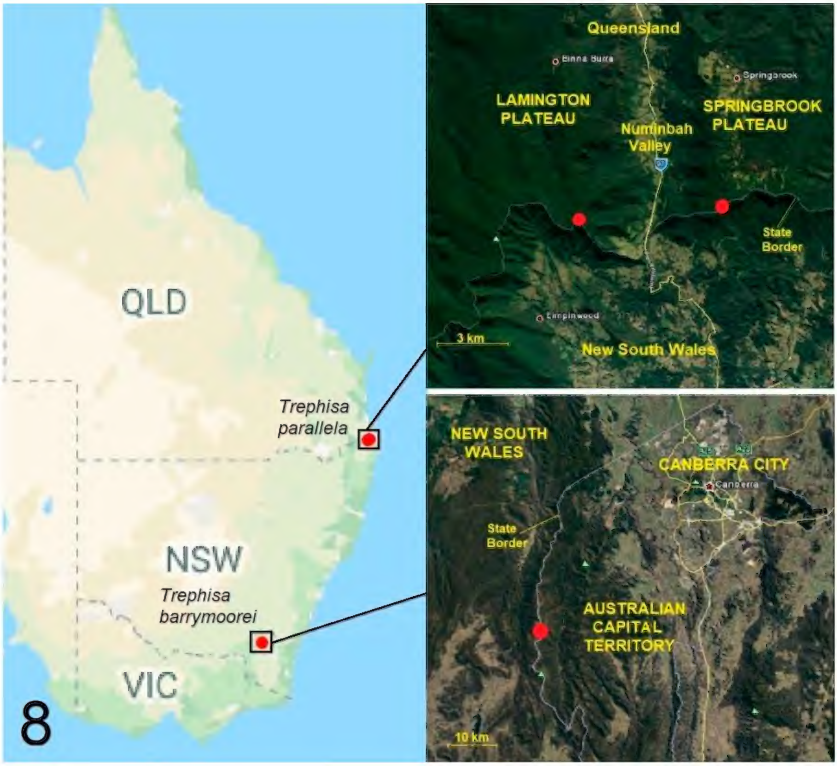


Fig. 8. Distributional map for *Trephisa* spp. Finer scale maps to right indicate collecting localities relative to State or territorial borders and geographical features mentioned in the text.

Distribution and habitat. The type locality lies on the New South Wales-Queensland border, Lamington Plateau (Fig. 8). Darlington wrote in his collecting diary, 'the higher parts of the [McPherson] range reach about 4000' ... and on the very highest points are very small areas of almost pure *Nothofagus* forest.' This is the northern limit of *Nothofagus* in Australia, although the genus occurs again on high mountains in New Guinea. We worked out from Binna Burra because I had worked the other end of the range in 1932. Above Binna Burra we took what is probably now a new genus of small-eyed Pterostichini, under deep stones in the closed forest ... (G. Monteith pers. comm.).' His new genus of Pterostichini would have been these specimens, as Darlington included moriomorphines within Pterostichini (Darlington 1971: 186). Two other specimens have been collected more recently from the Springbrook Plateau 6 km east of the type locality (Fig. 8). These specimens were also collected from under deeply embedded stones within closed *Nothofagus* forest, confirming that this microphthalmic species is a deep-soil dweller. The two known localities, both at higher elevations, are separated by the deep Numinbah Valley.

Discussion

Recognition that *Trephisa barrymoorei* shares numerous synapomorphies with *T. parallela* allows us to better define the groundplan of the genus. Based on preliminary results of an ongoing phylogenetic analysis of moriomorphine genera (JKL unpubl. data), the two *Trephisa* species comprise the sister group to *Teraphis*, represented by two examined species: *Ter. melbournesis* Castelnau and *Ter. crenulatus* (Sloane). These *Teraphis* species differ from the *Trephisa* above by: 1, labial paraglossae only moderately elongate, apex extended only half the distance from base beyond broadly truncate, well sclerotised ligular margin; 2, ocular lobe more protruded, lobe and gena meeting at an obtuse angle demarcated by a shallow groove; 3, pronotal median longitudinal impression more broadly impressed, the depression extended laterally onto disc; 4, pronotal laterobasal depression broad, extended from medial longitudinal impression to lateral convexity inside hind angle without a lateral tubercle between; 5, two dorsal elytral setae consistently present instead of one (although *Trephisa* setation is unstable with two setae unilaterally present rarely); 6, elytral basal groove evenly recurved, without the undulations at strial bases observed in *Trephisa* spp; 7, elytral strial punctation larger, the punctures expanding strial width; 8, elytral marginal depression broader, explanate from humerus to elytral midlength; 9, mesepisternum smooth to moderately punctate along its deepest dorsoventral excavation, versus distinctly punctate across the entire surface in *Trephisa* spp; 10, metepisternal-metepimeral suture present, distinct, not reduced; and 11, tarsomeres glabrous above, not bearing the sparsely distributed, elongate setae observed in *Trephisa* spp. Thus Moore's (1977) decision to maintain *Trephisa* and *Teraphis* as distinct taxa is corroborated.

That *Teraphis* and *Trephisa* are sister taxa is supported by several characters, including: 1, small eyes with ocular lobe ratios less than 0.87 and fewer than 20 ommatidia across a horizontal diameter of the eye; 2, ligula broadly truncate with a well sclerotised margin; 3, pronotal front angles protruded, narrowly rounded to subangulate; 4, all eight elytral striae punctate to various degrees; 5, mesotibiae robust, apically expanded; 6, lateral reaches of abdominal ventrites 1-3 punctate; 7, sutures between abdominal ventrites 3-6 deep and lined with distinct punctures; and 8, apical male abdominal ventrite with 3 setae each side for a total of 6 marginal setae. Of these characters, four can be assessed only by examination of the body's ventral surface, meaning that they would be overlooked in a quick perusal of specimens in a drawer. Others such as degree of strial development and punctation vary dramatically across the tribe Moriomorphini, so they can assist in grouping these genera only in concert with the other characters.

Due to the immense diversity of insects and the paucity of insect systematists, specimens can lie in institutional collections for generations before they are validly described. That Philip Darlington did not recognize *Trephisa barrymoorei* as being generically distinct from previously described moriomorphine taxa is attested to by his placing a hand-written label '*Phersita* #2' on the specimen presently designated as the holotype of this newly described species: *Phersita* being Sloane's (1903) unjustified replacement name for the previously described *Teraphis* Castelnau (Moore *et al*. 1987). Barry Moore visited the Museum of Comparative Zoology on 10 October 1961, recording the purpose of his visit in the MCZ guest book as 'to look at Carabidae (C.W. Farnum pers. comm.).' He would have consulted with Prof. Darlington at that time, with Darlington allowing him to take on loan four specimens of the 'new genus of small-eyed Pterostichini (Darlington field diary, May 1957)' from Binna Burra, which Moore (1963) subsequently described as *Trephisa parallela*. Casting his eye over Darlington's '*Phersita* #2' during his museum visit did not result in Moore taking those specimens on loan, perhaps because he agreed that those specimens represented only another species of *Teraphis*? The characters differentiating *Teraphis* from the genus Moore described two years later are subtle, often involving difficult to examine characters of the mouthparts and underbody: just the sort of characters to miss during a brief museum visit to the very large Darlington collection of Australian Carabidae. Yet by borrowing, studying and subsequently describing the four specimens as *Trephisa parallela*, Moore established criteria by which any appropriate species could be assigned to the genus. Additional information provided by the new species described above enhances support both for the monophyly of *Trephisa* Moore and for the sister-group relationship between the genera *Trephisa* and *Teraphis*.

Acknowledgements

I thank C.W. Farnum for searching the MCZ guest book to document Barry Moore's 1961 visit with Prof. Darlington and D.R. Maddison for providing access to the Springbrook Plateau specimens of *T. parallela*. Special thanks go to Geoff Monteith for providing information from Darlington's collecting diary, his own collections of *Trephisa parallela* and for developing Figure 8 that presents the geographical context for the various collecting localities. Timely and constructive reviews were provided by N.A. Guthrie and K.W. Will.

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A NEW GENUS AND THREE NEW SPECIES OF THE BEMBIDIINE SUBTRIBE ANILLINA (COLEOPTERA: CARABIDAE) FROM AUSTRALIA

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Abstract.

Three new species of anilline Bembidiini from Australia are described. Two species belong to the genus *Illaphanus* Macleay, 1865: *I. walfordi* **sp. n.** and *I. oakviewensis* **sp. n.**, while the third is a new genus *Parillaphanus* **gen. n.**: *P. mooreanus* **sp. n.** The new species are compared with related species and the new genus is inserted into the most recent key to the genera of Australian Anillina.

Introduction

Very few species of the blind carabid beetles of the Subtribe Anillina (Bembidiini) had been recorded from Australia until quite recently, when Giachino (2005) described three new genera (*Austranillus, Pseudillaphanus* and *Tasmanillus*) and 32 new species, mostly in the genus *Illaphanus* Macleay, 1865. All were recorded from near coastal eastern Australia and Tasmania, where the species have been found in ground litter of rain forest and rather wet sclerophyll forest. Almost all species share a distinct body shape, with a rather wide, cordate prothorax and short and wide, ovate elytra. More recently, Baehr and Main (2016) described a completely different and diverse anilline fauna from Western Australia. These were all collected, by specialised methods, in deep bores drilled in layered sandstone by mining companies exploring iron ore-containing rocks in the Pilbara Region and in central southern Western Australia. Altogether, 17 species were detected and arranged in six genera. Body shape and structure of all these Western Australian underground species is totally different from those species occurring in eastern Australia. Their biology is also very different from that of the eastern species.

Although the Anillini of wet eastern Australia seem to be better known than those of arid Western Australia, many species in eastern Australia are still known from either single specimens or from just a single locality. Thus, they appear to be mostly short-range endemics, as the western species are. However, the actual species inventory is certainly still far from fully known and it was not surprising to find two undescribed species of *Illaphanus* in collections of Australian Museums. The detection of a new genus and species from near Darwin in the Northern Territory was, however, unexpected.

The aim of the present paper is to describe these new species and also to encourage Australian collectors to pay attention to this interesting beetle group and to intensify collecting by use of appropriate sampling methods, especially by systematically sifting ground litter by hand or by Berlese extraction.

Materials and methods

The genitalia were removed from specimens relaxed overnight in a jar under moist atmosphere, then cleaned for a short while in hot 4% KOH. Photographs were taken with a Canon 5DS camera equipped with bellows and a Mitutoyo 10x ELWD Planapo objective and Helicon focus software and then edited with Corel Photo Paint X14. Measurements were taken with an ocular micrometer in a stereomicroscope. Overall length was measured from apex of labrum to apex of elytra. Pronotal length was measured along midline and its basal width across the extreme tips of the basal angles. Measurements and ratios are shown in Table 1.

Table 1. Comparison of measurements and ratios of the new species described in the present paper. N = number of specimens measured, l = body length in mm, w/l pr = ratio width/length of pronotum, d/b pr = ratio width diameter/base of pronotum, l/w el = ratio length/width of elytra.

Species	N	l	w/l pr	d/b pr	l/w el
I. walfordi	6	1.08-1.14	1.09-1.14	1.26-1.31	1.57-1.61
I. oakviewensis	1	1.0	1.21	1.40	1.57
P. mooreanus	1	0.89	1.17	1.18	1.77

Types are in the Australian National Insect Collection, Canberra (ANIC) and Queensland Museum, Brisbane (QMB), with some paratypes in the working collection of the author in the Zoologische Staatssammlung, München, Germany (CBM).

Genus *Illaphanus* Macleay, 1865

Illaphanus Macleay, 1865: 156. – Moore *et al*. 1987: 136; Giachino 2005: 139; Lorenz 2005: 204.

Type species. *Illaphanus stephensii* Macleay, 1865, by monotypy.

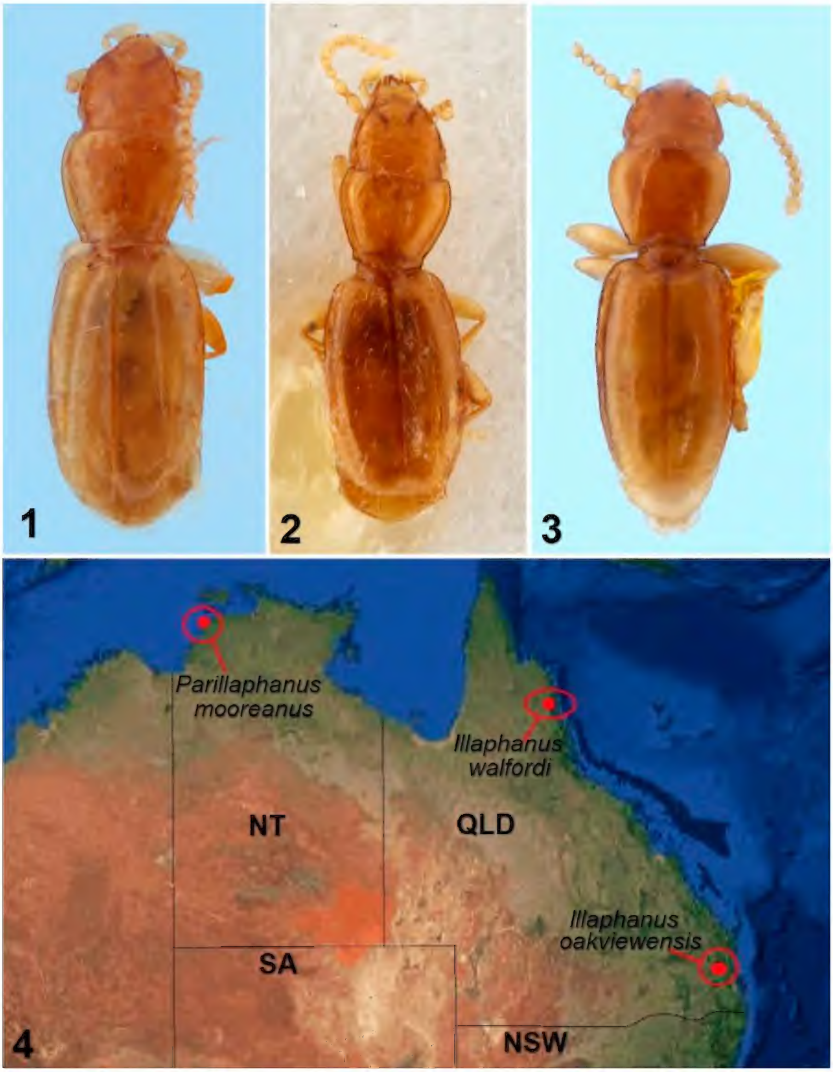
Diagnosis. Genus of Anillina, characterised by small body size (usually < 1.5 mm), absence of eyes, depigmented surface, sparsely pilose elytra, cordate prothorax, rather short and wide, ovoid elytra, reduction of most elytral striae and presence of an elongate sulcus on each elytron.

The genus thus far contains 30 species, which are distributed from northern Queensland along the east coast of Australia to southern Victoria and Tasmania, including Norfolk and Lord Howe Islands.

Illaphanus walfordi sp. n.

(Figs 1, 5-6)

Type material. Holotype ♂: 'Mt Windsor Tableland via Mt Carbine, 27 Dec. 1984, N.QLD, A.Walford-Huggins / ANIC Berlesate 1074. rainforest leaf litter' (ANIC). *Paratypes*: 4 ♂♂, 15 ♀♀, same data (ANIC, CBM).



Figs 1-4. New Australian Anillina (Carabidae): (1) *Illaphanus walfordi* **sp. n**. habitus, body length 1.10 mm; (2) *Illaphanus oakviewensis* **sp. n.** holotype ♀, body length 1.0 mm; (3) *Parillaphanus mooreanus* **sp. n.** holotype ♀, body length 0.89 mm; (4) distribution map of the three new species.

Diagnosis. Very small species with the character states of the *windsori* group of Giachino (2005); distinguished from the sympatric *I. windsori* Giachino, 2005, by smaller body size, narrower prothorax and elytra and differently shaped aedeagus, particularly of its spex.

Description. Measurements: Length: 1.08-1.14 mm; width: 0.37-0.39 mm. Ratio width/length of pronotum: 1.09-1.14; width of base/width of apex of pronotum: 1.26-1.31; ratio length/width of elytra: 1.57-1.61; ratio length/ width of 10th antennomere: 1.0.

Colour (Fig. 1). Upper and lower surfaces more or less pale red; palpi, antennae and legs dark yellow.

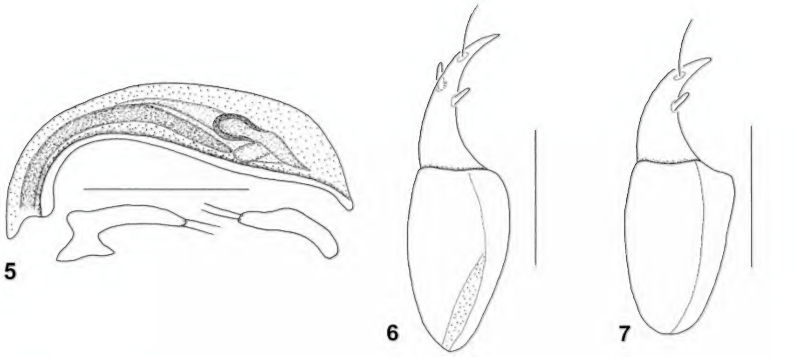
Head (Fig. 1). Slightly narrower than pronotum, short and wide, laterally convex. Upper surface gently convex. Frons behind clypeal suture on either side with a rather deep, circular impression. Neck wide. Clypeus bisetose, setae elongate. Labrum straight at apex, 6-setose. Subapical palpomere of maxillary palpus relatively wide, apical palpomere fairly elongate. Antenna very short, median antennomeres globose, about as long as wide. Frons with an elongate seta at either side, two elongate supraorbital setae present. Surface very sparsely pilose, pilosity markedly elongate, erect. Also lateral margin of head with sparse, elongate, erect pilosity. Microreticulation apparently absent, surface glossy.

Prothorax (Fig. 1). Rather narrow, cordiform, slightly wider than long, widest at about apical third. Apical margin straight, apical angle very slightly produced; lateral margin evenly convex, immediately in front of the angulate basal angle slightly concave. Base narrow, straight. Apex and base not margined, lateral sulcus narrow but distinct, not widened basad. Disc fairly convex. Median line barely recognizable. Anterior transverse sulcus absent, the posterior sulcus moderately deep, v-shaped. No distinct basal grooves visible. The anterior marginal seta situated at about apical sixth, the posterior seta located slightly in front of the basal angle. Surface with sparse, fairly elongate, erect but slightly anteriad declined pilosity. Microreticulation only in middle at apex and base perceptible, disc glossy but with some scattered punctures.

Elytra (Fig. 1). Elongate, gently ovoid, rather wide at humerus, disc rather depressed. Humerus obtusely angulate, base slightly oblique. Lateral margin gently convex, pilose, denticulate at least in anterior half. Apex convex. No striae perceptible. Discal sulcus deep, very conspicuous. Only very superficial traces of microreticulation visible, surface glossy, moderately sparsely punctate. Disc with one discal puncture and seta, situated in front of middle. Surface with rather sparse, elongate, erect setae. Umbilical setae very elongate, the three humeral ones about equidistant, the 6th seta somewhat displaced mediad to the disc. Metathoracic wings absent.

Lower surface. Sparsely pilose. Metepisternum rather short, *ca* 1.3 x as long as wide at apex. Terminal sternum in male bisetose, in female quadrisetose.

Legs. Short, densely pilose. Profemur with a tiny tooth at about middle of lower surface. In male two basal tarsomeres of protarsus barely widened and sparsely pilose underneath.



Figs 5-7. Genitalia of new Anillina: (5) *Illaphanus walfordi* sp. n. aedeagus, left side, left and right parameres; scale bar: 0.1 mm; (6) *Illaphanus walfordi* sp. n. female gonocoxites 1 and 2 of paratype ♀; scale bar: 0.05 mm; (7) *Parillaphanus mooreanus* sp. n. female gonocoxites 1 and 2 of holotype ♀; scale bar: 0.05 mm.

Male genitalia (Fig. 5). Aedeagus fairly elongate, moderately wide; basal part markedly curved. Apex acute, triangular, distinctly bent downwards. Internal sac with a somewhat horseshoe-shaped, narrow sclerite in middle and with some additional, slightly sclerotised folds. Both parameres elongate, bisetose.

Female gonocoxites (Fig. 6). Gonocoxite 1 large, without setae at the apical margin. Gonocoxite 2 elongate, curved, with acute apex, with one small dorsomedian ensiform seta in apical fourth, one small ventrolateral ensiform seta about at middle and an elongate nematiform seta near apex that originates in a pit.

Variation. Some minor variation noted in shape of pronotum and elytra.

*Etymology***.** The name is a patronym in honour of the collector, Alan Walford-Huggins.

Distribution (Fig. 4). Known only from the Windsor Tableland, an isolated rainforest plateau ranging from 900-1300 m altitude and situated 40 km NW of Mossman in NE Queensland.

Collecting circumstances. Sampled by Berlese extraction of litter in rain forest. Altitude not mentioned.

Relationships. On the basis of shape and structure of the aedeagus, *I. walfordi* is related to *I. windsori* Giachino, 2005.

***Illaphanus oakviewensis* sp. n.**

(Fig. 2)

Type material. *Holotype* ♀: 'AUST:QLD:SEQ Oakview SF summit, 26 May 2002, G.B. Monteith. / QM Berlesate No.1066, 26°10'Sx152°20'E, rainforest, 600 m. sieved litter. / *ILLAPHANUS*' (In QMB, Reg. No.QMT244715).

Diagnosis. Very small species, with two discal setae on the elytra, belonging to the *stephensii* group of Giachino (2005). Distinguished from the other species of the *stephensii* group, except *I. stephensii* Macleay, 1865, by smaller body size and from *I. stephensii* by narrower prothorax, which has sides distinctly sinuate near base.

Description. Measurements: Length: 1.0 mm; width: 0.35 mm. Ratio width/length of pronotum: 1.21; width of base/width of apex of pronotum: 1.40; ratio length/width of elytra: 1.57; ratio length/width of 10th antennomere: 1.0.

Colour (Fig. 2). Upper and lower surfaces, palpi, antennae and legs dark yellow.

Head (Fig. 2). Slightly narrower than pronotum, short and wide, laterally convex. Upper surface gently convex. Frons behind clypeal suture on either side with a rather deep, circular impression. Neck wide. Clypeus bisetose, setae elongate. Labrum straight at apex, 6-setose. Subapical palpomere of maxillary palpus wide, apical palpomere short. Antenna very short, median antennomeres globose, about as long as wide. Frons with an elongate seta at either side, two elongate supraorbital setae present. Surface sparsely pilose, pilosity moderately elongate, erect. Lateral margin of head also with sparse, elongate, erect pilosity. Microreticulation apparently absent, surface glossy.

Prothorax (Fig. 2). Rather narrow, cordiform, slightly wider than long, widest at about apical third. Apical margin straight, apical angles very slightly produced; lateral margin evenly convex, slightly concave immediately in front of the angulate basal angle. Base narrow, straight. Apex and base not margined, lateral sulcus narrow but distinct, not widened basad. Disc fairly convex. Median line faint. Anterior transverse sulcus absent, the posterior sulcus moderately deep, v-shaped. No distinct basal grooves visible. The anterior marginal seta situated at about apical sixth, the posterior seta located slightly in front of the basal angle. Surface with rather short, sparse, erect pilosity that is slightly declined anteriorly. Microreticulation only perceptible in middle at apex and base, disc glossy but with some scattered punctures.

Elytra (Fig. 2). Rather elongate, gently ovoid, fairly wide at humerus, disc rather depressed. Humerus obtusely angulate, base slightly oblique. Lateral margin gently convex, pilose, denticulate at least in anterior half. Apex convex. No striae perceptible. Discal sulcus deep, very conspicuous. Only very superficial traces of microreticulation visible, surface glossy, moderately sparsely punctate. Disc with two discal punctures and setae, situated in front of middle and close to apex, that are difficult to detect when setae are broken. Surface with rather sparse, elongate, erect setosity. Marginal setae very elongate. Metathoracic wings absent.

Lower surface. Sparsely pilose. Metepisternum rather short, *ca* 1.3 x as long as wide at apex. Terminal sternum in female quadrisetose.

Legs. Short, densely pilose. Squamosity of the male protarsus unknown.

Male genitalia. Unknown,

Female gonocoxites. Not dissected to avoid damage to the single specimen. Probably similar to those of *I. walfordi*.

Variation. Unknown.

Etymology. The name refers to the type locality, Oakview State Forest in southeastern Queensland.

Distribution (Fig. 4). Oakview State Forest, 33 km WNW of Gympie, southeastern Queensland. Known only from the type locality.

Collecting circumstances. Holotype sampled by Berlese extraction of litter in rain forest at 600 m.

Relationships. A species of the *stephensii* group *sensu* Giachino (2005), On the basis of its small size and body shape, it is most similar to and perhaps also related to *I. stephensii* Macleay, 1865.

***Parillaphanus* gen. n.**

(Fig. 3)

Type species. *Parillaphanus mooreanus* sp. n., by monotypy.

Diagnosis. Genus of Anillina, characterised by very small body size (< 1 mm), absence of eyes, depigmented surface, sparsely pilose elytra, cordate prothorax without a marginal sulcus, elongate, slightly oviform elytra, reduction of all elytral striae and absence of a longitudinal sulcus on the elytra. Distinguished from *Illaphanus* Macleay, 1865 by absence of the elytral sulcus, from the southern *Pseudillaphanus* Giachino, 2005 and *Tasmanillus* Giachino, 2005 by smaller size, much narrower prothorax and elongate elytra, and from *Austranillus* Giachino, 2005 and most genera described from Western Australia by absence of the marginal sulcus on the pronotum and by some differences in shape of head, pronotum and elytra, as exemplified in the key below.

A single species, *Parillaphanus mooreanus* **sp. n.**, recorded from near Darwin, Northern Territory**.**

Description. For the generic description see the description of the type species.

Etymology. The name refers to the difference between *Illaphanus* and this genus, which mainly refers to the absence of the elytral sulcus that is present in *Illaphanus*.

Relationships. According to body shape and general surface structure, the new genus belongs to the *Illaphanus* lineage within the Australian Anillina but takes a rather unique position within this lineage, based mainly on the

absence of the lateral sulcus of the pronotum, absence of the elytral sulcus and the elongate though slightly oviform shape of the elytra.

***Parillaphanus mooreanus* sp. n.**

(Figs 3, 7)

Type material. *Holotype* ♀: 'N.T. Darwin, Lameroo Beach, 9.xi.1972, N. Forrester / ANIC Berlesate 443, 12º28'S x 130º50'E' (ANIC).

Diagnosis. Very small species, without elytral sulcus; distinguished from all other Australian genera without elytral sulcus by very small body size, strongly cordiform pronotum lacking the lateral sulcus and elongate but oviform elytra**.**

Description. Measurements: Length: 0.89 mm; width: 0.28 mm. Ratio width/length of pronotum: 1.17; width of base/width of apex of pronotum: 1.18; ratio length/width of elytra: 1.77; ratio length/width of 10th antennomere: 0.9.

Colour (Fig. 3). Upper and lower surfaces pale red; palpi, antenna and legs dark yellow.

Head (Fig. 3). Slightly narrower than pronotum, short and wide, laterally convex. Upper surface gently convex. Eye absent. Frons behind clypeal suture on either side with a rather deep, circular impression. Neck wide. Clypeus bisetose, setae elongate. Labrum straight at apex, 6-setose. Subapical palpomere of maxillary palpus wide, apical palpomere short. Antenna very short, median antennomeres globose, wider than long. Frons with an elongate seta at either side, two elongate supraorbital setae present. Surface barely pilose. Lateral margin of head with sparse, elongate, erect pilosity. Microreticulation absent, surface glossy.

Prothorax (Fig. 3). Rather narrow, cordiform, slightly wider than long, widest at about apical third. Apical margin straight, apical angle not produced; lateral margin evenly convex, immediately in front of the angulate basal angle very slightly concave. Base narrow, straight. Apex and base not margined, lateral sulcus absent. Disc fairly convex. Median line faint. Anterior transverse sulcus absent, the posterior sulcus fairly deep, v-shaped. No distinct basal grooves visible. The anterior marginal seta situated about at apical eighth, the posterior seta located immediately in front of the basal angle. Surface with very sparse, short, erect pilosity that is slightly declined anteriorly. Microreticulation apparently absent, disc very glossy but with some scattered punctures.

Elytra (Fig. 3). Elongate, gently ovoid, rather wide at humerus, disc rather depressed. Humerus obtusely angulate, base slightly oblique. Lateral margin gently convex, pilose and coarsely denticulate, at least in anterior half. Apex convex. No striae perceptible. Discal sulcus absent. Microreticulation absent. Surface glossy, moderately densely punctate. Disc with two discal punctures

and setae, situated about at middle and close to apex, that are very difficult to detect because the setae are broken in tht Type. Surface with fairly dense, short, erect setae that are slightly inclined anteriad and are arranged in rather regular rows. Marginal setae very elongate. Metathoracic wings absent.

Lower surface. Sparsely pilose. Metepisternum rather short, *ca* 1.3 times as long as wide at apex. Terminal sternum in female quadrisetose.

Legs. Short, densely pilose. Squamosity of the male protarsus unknown.

Male genitalia. Unknown.

Female gonocoxites (Fig. 7). Gonocoxite 1 compact, without setae at the apical margin. Gonocoxite 2 moderately elongate, curved, with acute apex, with one small ventrolateral ensiform seta slightly above middle and one elongate nematiform seta near apex that originates in a pit. The dorsomedian ensiform seta apparently absent.

Variation. Unknown.

Etymology. The name is a patronym in honour of the late Dr Barry Moore, unexcelled authority on taxonomy and systematics of Australian carabid beetles.

Distribution (Fig. 4). Northern Territory, near coast. Known only from the type locality, which is a beach beside the central business area of Darwin City.

Collecting circumstances. Holotype sampled by Berlese extraction at sea level. Environment type unknown.

Identification

Identification of both new species of *Illaphanus* should be quite easy by use of the diagnoses. The new genus *Parillaphanus* is inserted into the recent key to the Australian genera (Baehr and Main 2016). Using this key, couplet 8 is easily reached, which must be changed as follows:

8. Body size very small, length < 1.0 mm; head narrower than prothorax; pronotum without marginal sulcus; elytra elongate but somewhat oviform (Fig. 3). n. NT ..... *Parillaphanus* **gen. n.**

– Body size larger, length > 1.1 mm; pronotum with distinct marginal sulcus; when elytra elongate and somewhat oviform, head as wide as prothorax. Not in NT 8a

8a. = couplet 8 of Baehr and Main key.

Remarks

The detection of a new genus and three new species of Anillina demonstrates that even in eastern Australia, where the Anilline fauna was thought to be reasonably well known, additional species can be found, even in areas

already searched for Anillina, *e.g.* Windsor Tableland. The other new species of *Illaphanus*, *I. oakviewensis*, however. was sampled in an area from which no previous record was available. Moeover, it is the first species of the *stephensii* group, in the sense of Giachino (2005), from Queensland and from an area far more north than any other species of this group.

Even more surprising, however, is the discovery of a new genus and species in the Northern Territory, in an area that, at first glance, would not be believed to house any anilline species. However, previously this was also the case for Western Australia, from where now a quite rich anilline fauna is recorded (Baehr and Main 2016).

Acknowledgements

My sincere thanks are due to Christine Lambkin, Susan Wright and Geoff Monteith (Queensland Museum, Brisbane) and to Cate Lemann (Australian National Insect Collection, Canberra) for the kind loan of the specimens. Geoff Monteith also kindly prepared the distribution map using the on-line Atlas of Living Australia facility.

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PSEUDORYCTES MAGNIFICOLLIS SP. N. FROM WESTERN AUSTRALIA AND NEW RECORDS FOR OTHER SPECIES OF *PSEUDORYCTES* SHARP (COLEOPTERA: SCARABAEIDAE: DYNASTINAE)

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'Whenever I hear of the capture of a rare beetle, I feel like an old war-horse at the sound of a trumpet' – Charles Darwin

Dedicated to the memory of the late
Barry Philip Moore (1925-2015), a war-horse.

Abstract

Pseudoryctes magnificollis **sp. n.** is described from a unique male taken in the Northern Kimberley region of Western Australia. Additional records are given for other *Pseudoryctes* Sharp species. A modified key to species of *Pseudoryctes* is provided to accommodate *Pseudoryctes storeyi* Carne, 1980 and *Pseudoryctes magnificollis*.

Introduction

Sharp (1873) established *Pseudoryctes* as a monotypic genus for his *P. mullerianus*, later found to be a homonym of *P. mullerianus* (White, 1859) and replaced by Carne (1957) by its junior synonym *P. dispar* Sharp, 1875. Further species were added by Macleay, Arrow, Blackburn and Lea, so that Carne (1957) could consider 15 species. Carne (1957) first split off, as *Cryptoryctes* Carne (now *Carneoryctes* Özdikmen, 2009), eight species that have visible mandibles and labrum, 10-segmented antennae, weakly setose antennal clubs, a weakly convex and smooth pronotum, the first segment of the hind tarsi weakly dilated and much shorter than segments 2-5 combined, bicarinate hind tibiae and very unequal hind tibial spurs. He then described two new species of *Pseudoryctes*, later (Carne 1980) adding *P. storeyi* to make nine valid species and one synonym (Endrödi 1985, Cassis and Weir 1992, Dechambre 2005) and adding further distribution records.

All species are notable for the males, which have elaborate pronotal armature arranged around a deep and extensive excavation. The species are distributed primarily across the northern half of Australia. All are poorly represented in collections, usually only by single individuals or a small series. Published distributional data for the nine described species illustrates the infrequency of collected specimens, from 1-8 locations. Females are recorded only for *P. dispar* Sharp. Biological data were generally not recorded and most specimens were collected at settlements. Thus, it is not surprising that *P. storeyi* and *P. magnificollis* **sp. n.**, two large and striking species, were discovered only comparatively recently.

Abbreviations. DAFWA – Department of Agriculture and Food Western Australia, Perth, WA; NMV – National Museum of Victoria, Melbourne,

Victoria; PMH – Collection of Paul M. Hutchinson, Perth, WA; **WAM** – Western Australian Museum, Perth, WA.

***Pseudoryctes magnificollis* sp. n.**

(Figs 1-6)

Type material. Holotype ♂, WESTERN AUSTRALIA: Beta Creek, 3 km E from King George River, 14º16'S, 127º19'E, 19.ix.1996, A.F. Longbottom. In WAM; Entomology Reg. No. E83857.

Description of holotype. Male: Length (apex of anterior pronotal horn to tip of elytra) 23 mm, width of pronotum 16.5 mm, width at elytra 13 mm. Bicoloured species. Head and pronotum shiny dark brown. Ventral surface of thorax, abdomen and legs light brown. Elytra black with basal half, lateral margins and suture suffused dark brown. Apices of thoracic armature and carina black. Apices of all leg segments and structures black.

Head. Mentum broad, globular, narrowed, with compressed ligula. Clypeus subrectangular. Clypeofrontal ridge sinuate, slightly raised medially. Apex of clypeus not parallel with clypeofrontal ridge but produced anteriorly at middle with rounded anteriorlateral angles. Anterior and lateral margins elevated steeply at 90º to surface. Surface finely micropunctate and glabrous. Raised margins of clypeus at 90º to plane of frons, resulting in plane of clypeus less than 90º from plane of frons. Frons arcuate through 90º from clypeofrontal ridge to base. Disc of frons micropunctate, glabrous. Short black setae on ocular canthi. Antennal club almost equal to length of shaft.

Thorax. Pronotum deep, glabrous, excavation rising steeply to basal margin. Basal ridge obsolete in median third. Anterolateral angles broadly rounded. Basolateral angles well defined. Anterior quarter of excavation micropunctate; median half rugulose, not reaching apex of inner face of mediolateral armature; posterior quarter micropunctate; sides micropunctate, bearing long setae in area at base of mediolateral armature. Anterior margin adjacent to eyes angulate, giving rise to short, acute anterior projection. Primary horn at midlength of pronotum steeply rising vertically, angled toward centre of pronotum. Inner face divergent at base and arcuate in dorsal half in anterior view; outer face arcuate distally in basal half and proximally in apical half. Apical portion bearing carina to apex on external face. Apex obliquely truncate with anterior edge acute. Secondary horn arising independently, originating anterior to primary horn and rising to simple apex anteriorly, pronotal concavity ridge continuing to apex. Laterally at midlength with carina arising posterior to primary horn in anteroventral direction and abruptly terminating at midlength of pronotum. Carina without rise to node, not encircling a fovea. Anteromedial projection long, compressed, narrow, parallel, projecting beyond head. In lateral view, ventral and dorsal edges divergent with truncated apex. Apex sinuate at base, small bifurcation dorsally and finely depressed longitudinal midline.

Figs 1-3. Holotype male of *Pseudoryctes magnificollis* **sp. n.**, median length 23 mm: (1) dorsal view; (2) ventral view; (3) lateral view.

Figs 4-6. Holotype male of *Pseudoryctes magnificollis* **sp. n.**: (4) frontal view; (5) aedeagus, lateral view; (6) aedeagus, dorsal view.

Scutellum strigose at basal half, becoming obsolete at evenly rounded apex. Sparse pilosity on basal third.

Elytra. Sutural striae linear-punctate. Surface with barely discernible micropunctures, scattered near suture. Elytra fringed with short cilia that are longer toward apex. Base of elytra with long pilosity laterally.

Legs. Anterior tibia tridentate with teeth evenly spaced. Structure and shape as in *P. wilsoni* Carne (1957, fig. 425). All coxae clothed in long, fine, yellow pilosity. Mesotibiae and metatibiae unicarinate. Metalegs stout; femur with dense, long, fine yellow pilosity. Metatibial carina from midlength obliquely to distal margin. Distal cilia short, blunt medially, very long, fine, acute laterally, approximately same as width, numbering approximately 60. Distal spurs subparallel, with rounded apex, same length as first 2 tarsal segments. First tarsal segment dilated. Tarsal claws simple, even. Aedeagus as Figs 5-6.

Abdomen. Prosternal process barely surpassing coxa, posteriorly recurved at apex. Entirely covered with long, fine pilosity. Metathorax covered in long, fine yellow pilosity. Abdominal segments sparsely pilose laterally, glabrous

across middle. Pygidium sparsely micropunctate in middle, some punctures across base. Long, fine pilosity across base and lateral regions. Apical ridge glabrous in median third and setose at sides.

Female: unknown.

Etymology. Derived from the Latin *magnus,* meaning large and *collaris,* meaning neckband. *Magnificollis* therefore refers to the beetle's large and spectacular pronotal armature.

Distribution and habitat. Pseudoryctes magnificollis is known only from Beta Creek in the Kimberley Region of Western Australia. The habitat there varies rapidly from dry, open sclerophyll woodlands to swampy paperbark, *Drosera* etc. areas. The beetle was collected at camp in the morning (almost certainly attracted by the lights). The area had received approximately 15 mm of rain 2 days prior (Alan Longbottom pers. com.).

Discussion. The holotype of *P. wilsoni* Carne was examined and the following characters can be added to Carne's (1957) description. Frons angulate at 45º from clypeofrontal ridge to base. Setae on ocular canthi black. Anterior pronotal margin arcuate and re-entrant angle adjacent to eye at 90º and not produced. Anteromedial projection not surpassing head, less than 1.5 times length of frons; ventrodorsally subparallel; truncated face V-shaped and 0.5 times clypeal length. Hind tibial carina extends into basal half, from there oblique towards apex. Apical ciliae numbering approximately 37. First segment of hind tarsus dilated to one quarter of its length.

In Carne's (1957) key, *Pseudoryctes magnificollis* keys to *P. wilsoni.* Later, Carne (1980) described *P. storeyi* and commented 'it is most closely related to *P. bidentifrons* Lea and *P. wilsoni* Carne, sharing with them the characters of a subrectangular clypeus and a dorsally glabrous pronotum. It differs from both of them in the configuration of its pronotal armature and in having the pronotum and elytra differently coloured'. Couplet 3 of Carne's (1957) key to *Pseudoryctes* is modified below to include both *P. storeyi* Carne, 1980 and *P. magnificollis* sp. n.

3(2) Clypeus and frons in same plane (figs 449 and 450 of Carne 1957); pronotum with pair of widely separated paramedian tubercles; fore tibia with lateral rows of setae interrupted between basal and intermediate tooth. Aedeagus as in figs 456 and 457 of Carne (1957). Length approximately 18 mm; Northern Territory ..... *bidentifrons* Lea

– Clypeus and frons not in same plane. Pronotum not bearing a pair of paramedian tubercles ..... 3(a)

3(a) Clypeus at approximately 45º from plane of frons. Bicoloured species. Pronotal armature consisting of one pair of widely divergent horns and a long anteromedial acuminate process with obliquely truncated face. Length 22-25 mm; Queensland ..... *storeyi* Carne

– Clypeus at approximately 90º to plane of frons. Unicolored or bicoloured species. Pronotal armature consisting of one pair of horns and a secondary pair located anteriorly. Anteromedial process with truncated face; Western Australia ..... 3(b)

3(b) Black species. Secondary pronotal horn arising from anterior base of primary horn. Anteromedial process dorsoventrally parallel and less than 1.5 times length of frons; face of process 0.5 times clypeal length. First segment of hind tarsi dilated to one quarter of its length; Western Australia ..... *wilsoni* Carne

– Bicoloured species. Secondary pronotal horn not arising from base of primary horn. Anteriomedial process dorsoventrally divergent and 2.5 times length of frons; face of process 3 times clypeal length. First segment of hind tarsi dilated over half of its length; Western Australia ..... *magnificollis* **sp. n.**

Distinguishing characters between *P. wilsoni* and *P. magnificollis* are summarised in Table I.

New locality records for other *Pseudoryctes* species

Upon inspection of *Pseudoryctes* specimens in various collections, the following unpublished Australian material was located:

Pseudoryctes bidentifrons Lea, 1926

1 ♂, Vanderlin Island, Northern Territory, 1.x.2001, G. Stokes / Dyn0518 (PMH).

Pseudoryctes dispar Sharp, 1875

1 ♂, Cape Conran, Victoria, 5.viii.1968, D.D. Giuliana / Scarabaeidae: Dynast. *Pseudoryctes dispar* Sharp E.B. Britton Det. 1970 / 70-3508 (WAM).

Pseudoryctes mullerianus (White, 1859)

1 ♂, Produce Road, Humpty Doo, Northern Territory, 13.x.1985, J.M. Waldock / inside house 9.30 am (WAM).

Pseudoryctes turritus (MacLeay, 1888)

1 ♂, [No locality], ex H.W. Brown Coll., Dyn1217 (PMH).

Pseudoryctes wilsoni Carne, 1957

1 ♂, Roebourne, NW Western Australia, H.W. Brown, ex H.W. Brown Coll. / Dyn1293 (PMH); 1 ♂, N Queensland / Agriculture [Dept.] Western Australia 9584 (DAFWA).

Table 1. Distinguishing characters between *Pseudoryctes wilsoni* Carne and *P. magnificollis* sp. n.

	***Pseudoryctes wilsoni* Carne, 1957**	***Pseudoryctes magnificollis* sp. n.**
Colour	Black.	Bicoloured, brown and black.
Head	Clypeofrontal ridge depressed in middle.	Clypeofrontal ridge not medially depressed.
	Anterior and lateral clypeal margins moderately raised.	Anterior and lateral clypeal margins strongly elevated.
	Raised clypeal margins and clypeal surface at 90° to plane of frons.	Raised clypeal margins at 90° to plane of frons but plane of clypeus less than 90° to plane of frons.
	Anterior clypeal margin parallel to clypeofrontal ridge.	Anterior clypeal margin not parallel to clypeofrontal ridge.
	Frons angulate at 45° from clypeo-frontal ridge to base.	Frons arcuate through 90° from clypeofrontal ridge to base.
Pronotum	Anterior pronotal margin adjacent to eye forming right-angle and not produced.	Anterior pronotal margin adjacent to eye acute and forming a small anteriorly directed projection.
	Anteromedial horn not projecting beyond head. Approx. 1.5 x length of frons.	Anteromedial horn distinctly projecting beyond head. Approx. 2.5 x length of frons.
	Anteromedial horn with dorsal and ventral surface subparallel	Anteromedial horn with dorsal and ventral surfaces distinctly divergent.
	Anterior face of anteromedial horn 'V'-shaped. Face 0.5 x length of clypeus.	Anterior face of anteromedial horn subparallel with minor bifurcation on dorsal margin. Face 3.0 x length of clypeus.
	Base of lateral pronotal horn gives rise to secondary anterior horn that projects vertically.	Secondary anterior horn arises independently of lateral pronotal horn and projects anteriorly.
Legs	Hind tibial carina extends to basal half of tibia.	Hind tibial carina limited to distal half of tibia.
	Hind tibial cilia numbering *ca* 37.	Hind tibial cilia numbering *ca* 60.
	Basal tarsomere of hind leg *ca* 4 x longer than wide.	Basal tarsomere of hind leg *ca* 2 x longer than wide.

Species of *Pseudoryctes* occur along coastal rivers or are generally coastal in distribution across high rainfall areas of northern Australia, from Roebourne in Western Australia (-20.771°S) to Chillagoe in Queensland (-17.154°S). Two locations fall outside these regions. Carne (1980) listed one male of

P. etunus Carne, 1957 from the drier interior of the continent at Broken Hill, New South Wales. The new record for *P. dispar* at Cape Conran, Victoria is dubious and further collecting is required to confirm the establishment of this species so far south.

Acknowledgements

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ALEPIDA, A NEW GENUS FOR SEVEN AUSTRALIAN SPECIES ATTRIBUTED TO *LEPIDIOTA* KIRBY, 1828 AND ONE NEW SPECIES (COLEOPTERA: SCARABAEIDAE: MELOLONTHINAE: MELOLONTHINI)

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Abstract

Alepida **gen. n.** is established for seven Australian species previously attributed to *Lepidiota* Kirby, 1828 (*L. crinita* Brenske, 1900; *L. froggatti* Macleay, 1887 (type species); *L. helleri* Moser, 1913; *L. hylaea* Britton, 1978; *L. picticollis* Lea, 1916; *L. stradbrokensis* Lea, 1919; *L. ultima* Britton, 1978; all **comb. n.**) and one new species *A. moorei* **sp. n.** *Lepidiota trichosterna* Lea, 1924 is confirmed as a junior synonym of *A. crinita.* The genus is distinguished by the absence of small, circular scales on the dorsal and ventral surfaces but with elongate, flattened, white setae grading into dense, more conventional brownish setae on the dorsal surface, long antennal clubs in males and male parameres that are bilaterally symmetrical or almost so. The status of the types of each of the previously described species is reviewed: lectotypes are designated for *L. crinita*, *L. froggatti*, *L. helleri* and *L. trichosterna*; the holotypes of *L. hylaea*, *L. picticollis* and *L. ultima* are confirmed as by original designation; the holotype of *L. stradbrokensis* is confirmed as by monotypy. Each of these eight valid species is rediagnosed /described and notes are given on their biologies and ecologies and their distribution across northeastern Australia. A key to species is provided.

Introduction

Lepidiota Kirby is a significant component of the Australian Melolonthini with 62 of the known 120 species attributed to it (Britton 1978, 1985, Houston and Weir 1992, Allsopp 1989, 1990, 1999, 2003, Allsopp and Watkins 1995). Species also occur through Solomon Islands, New Guinea, Indonesia, Philippines, Palau and southern China and on to the Indian subcontinent (Krajcik 2011). As its name suggests (Greek *lepidos* a scale and *iota* anything very small), a characteristic feature is the presence on the dorsal surface and at least part of the ventral surface of small, white near-circular scales each contained within a puncture. In eastern Australia, larvae of some species are important pests of sugarcane and other grasses (Allsopp *et al.* 1993, Miller and Allsopp 2000).

Britton's (1978) key to Australian *Lepidiota* separates the species into different phylogenetic groupings, albeit not formally identified. Occupying the last part of his key is a grouping of seven species from eastern Australia – *L. crinita* Brenske, *L. froggatti* Macleay, *L. helleri* Moser, *L. hylaea* Britton, *L. picticollis* Lea, *L. stradbrokensis* Lea and *L. ultima* Britton – that, instead of having small, circular scales on the dorsal and ventral surfaces, have elongate, flattened, white setae grading into dense, more conventional brownish setae. These seven species also have male parameres that are bilaterally symmetrical or almost so, quite unlike most of the other Australian species (compare Britton's figures 253-266 with his figures 151-175, 177-178 and 180-250). Three other particulars point to a generic difference.

Firstly, Miller and Allsopp (2000) showed strong similarities in the larval raster patterns within the *crinita-froggatti-picticollis* trio and distinct differences from other groups of pestiferous *Lepidiota.* Secondly, of the three *Lepidiota* species studied by Fletcher *et al.* (2008), the cuticular hydrocarbon compositions of *L. negatoria* Blackburn and *L. noxia* Britton were more closely related to each other than either was to that of *L. picticollis*. Thirdly, in their cladistic analysis of the sugarcane-damaging Melolonthini, Allsopp and Lambkin (2006) found it difficult to place adults of the *crinita-froggatti-picticollis* group in the same genus as the other Australian *Lepidiota* spp – they formed a distinct clade (Allsopp and Lambkin 2006, fig. 1A).

Here, I establish a new genus for these seven species and one new species, a system presaged (in part) by Lea (1916), who remarked that *L. picticollis* 'could only be referred to *Neolepidiota* [the misidentified Indian species *Holotrichia serrata* (F.)] or to *Lepidiota* (unless to a new genus)'. Perhaps this is also one group that Blackburn (1911) found difficult to incorporate in *Lepidiota* when he remarked 'I am doubtful, however, whether the species that I attribute to *Lepidiota* ought not to be divided into more than one genus'. However, *L. crinita*, *L. froggatti* and *L. helleri* do not appear in his uncompleted key to species of the genus published after his death (Blackburn 1912).

Locality records come from specimens in the following collections:

AM – Australian Museum, Sydney; ANIC – Australian National Insect Collection, Canberra; MMUS – Macleay Museum, University of Sydney, Sydney; QDAF – Queensland Department of Agriculture and Fisheries, Brisbane; QM – Queensland Museum, Brisbane; SAM – South Australian Museum, Adelaide; UQIC – University of Queensland Insect Collection, Brisbane (within QM); WAIC – Waite Agricultural Insect Collection, Adelaide; ZMB – Museum für Naturkunde, Berlin.

Comments are made on unverified records listed in the Atlas of Living Australia (ALA; *http://www.ala.org.au/)* that appear inconsistent with the above distributions; ALA records are not included on the maps.

My criteria for delimiting species are based on those published by Wheeler and Platnick (2000), whose phylogenetic species concept defines species as the smallest aggregation of (sexual) populations or (asexual) lineages diagnosable by a unique combination of characters.

Alepida gen. n.

Type species. Lepidiota froggatti Macleay, 1887, here designated.

Included species. *Lepidiota crinita* Brenske, 1900, *Lepidiota froggatti* Macleay, 1887, *Lepidiota helleri* Moser, 1913, *Lepidiota hylaea* Britton, 1978, *Alepida moorei* **sp. n.**, *Lepidiota picticollis* Lea, 1916, *Lepidiota stradbrokensis* Lea, 1919, *Lepidiota ultima* Britton, 1978.

Description. Mandibles not curved downwards at apices. Anterior face of clypeus shallow, depth > 8x width; anterior edge of clypeus from above slightly emarginate in middle to broadly bilobed. Antennae usually 10-segmented, rarely 9-segmented, club 3-lamellate, males with club slightly shorter or longer than segments 2-7 combined. Dorsal surface with elongate, flattened, white setae usually grading into dense, more conventional brownish setae; without circular white scales contained within their punctures on either dorsal or ventral surfaces; ventral thorax clothed with long, fine setae. Anterior edge of posterior femora not concave near base. Spurs of hind tibiae long and uniformly tapered. Tarsal claws each with a strong tooth near middle on concave side. Junctions between abdominal ventrites 2-5 much less obvious in the middle than at the sides. Male parameres bilaterally symmetrical or almost so.

Etymology. The name reflects the absence of scales in this genus. Feminine.

Diagnosis. *Alepida* occupies a position somewhere between the three dominant genera of Australian Melolonthini – *Lepidiota*, *Antitrogus* Burmeister and *Rhopaea* Erichson – and the smaller genus *Metatrogus* Britton. Species of *Alepida* lack the small, usually circular white scales characteristic of *Lepidiota*, have dense long setae on the ventral thorax and males have long antennal clubs and parameres that are not extremely distorted as in many species of *Lepidiota*. The 3-segmented antennal clubs distinguish species from most of those of *Antitrogus*, *Rhopaea* and *Metatrogus*. In addition, the parameres in males of *Rhopaea* are flanged near their apices and the anterior edge of the clypeus is uniformly convex in *Metatrogus*.

Alepida keys to either couplet 3 or couplet 6 in Britton's (1978) key to Australian Melolonthini and can be distinguished from *Lepidiota*, *Metatrogus* and *Antitrogus* using the characters above. I have refrained from developing a modified key pending further taxonomic changes in the tribe.

***Alepida crinita* (Brenske), comb. n.**

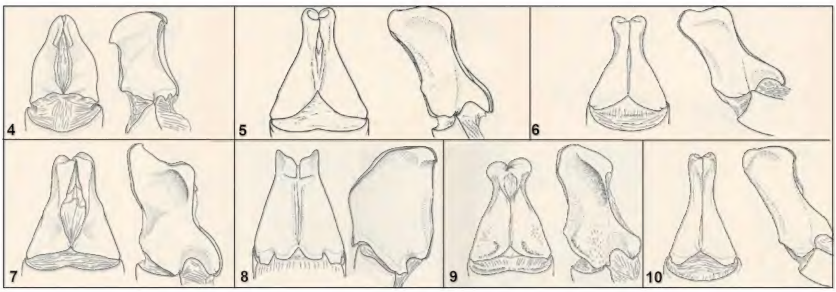
Bundaberg canegrub

(Figs 1-4, 19)

Lepidiota crinita Brenske, 1900: 623; Britton, 1978: 83, head and pronotum fig. 286F, aedeagus figs 255-256; Allsopp *et al.* 1993: 12, larval raster pattern fig. 4; Miller and Allsopp, 2000: 392, aedeagus fig. 17, larval raster pattern fig. 34; Sallam *et al.* 2007: 324, adult fig. 11.14, larval raster pattern fig. 11.13a. Type: Lectotype female (here designated), Burnett River [area], Queensland, in ZMB (Fig. 1).

Lepidiota trichosterna Lea, 1924: 309; Jarvis, 1927: 71, adult plate V, fig. 33; Britton, 1978: 83 (syn.). Type: Lectotype male (here designated), Gin Gin, Queensland, I.15470, in SAM (Fig. 3).

Figs 1-3. *Alepida crinita*: (1) *Lepidiota crinita*, lectotype female dorsal and labels, in ZMB (photographs courtesy of Bernd Jäger, © ZMB); (2) *Lepidiota crinita,* paralectotype male dorsal and labels, in ZMB (photographs courtesy of Bernd Jäger, © ZMB); (3) *Lepidiota trichosterna*, lectotype male dorsal and labels, in SAM (photographs by Eleanor Adams, © South Australian Museum Board 2018).



Figs 4-10. *Alepida* spp, aedeagi: (4) *A. crinita*; (5) *A. picticollis*; (6) *A. stradbrokensis*; (7) *A. froggatti*; (8) *A. helleri*; (9) *A. hylaea*; (10) *A. ultima*. Reproduced from Britton (1978) with permission from CSIRO Publishing.

Taxonomic notes. Brenske (1900) saw at least one male and one female but did not say how many of each gender he had. However, given that he gave no variation in the length of each gender, there was probably only one of each. He stated the type locality as 'Burnett-River'. There are two specimens in ZMB from Brenske's collection and marked as types: a female (Fig. 1), clearly marked as from Burnett River and collected by Semon and with Brenske's 'Type ♀' label; a male (Fig. 2), labelled only as 'Queensland' with a pink Brenske's type label. The female is undoubtably a syntype; the male probably is, but it lacks unequivocal collection data. Britton (1978) referred to a holotype male in ZMB from 'Burnett River' and this was repeated without comment by Houston and Weir (1992) and Miller and Allsopp (2000). Neither ZMB specimen bears a Britton label. For Britton's reference to a holotype to be accepted as a lectotype designation under Article 74.5 (ICZN 1999) Britton must have 'explicitly indicated that he was selecting from the type series that particular specimen to serve as the name-bearing type'. Given the discrepancy in the locality data between what was given by Britton and what is on the male specimen and that Britton did not explicitly select from the type series (he did not mention the female) or label a specimen, I consider that Britton's mention of a holotype does not constitute a valid lectotype designation. As the female specimen (Fig. 1) was undoubtably used by Brenske in his description and definitely comes from the type locality (Recommendation 74E), I hereby designate it the lectotype in order to preserve the stability of nomenclature. The male (Fig. 2) I consider a paralectotype. I have labelled both appropriately.

Lea (1924) did not state how many specimens of *L. trichosterna* he saw and what gender they were and he did not give a SAM registration number for a 'type'. Houston and Weir (1992) considered that the incorrect reference to a male holotype in SAM by Britton (1978) was a designation of a lectotype (Article 74.5, ICZN 1999); this was followed by Miller and Allsopp (2000). However, as Britton did not explicitly select a particular specimen from the type series of at least two specimens he mentioned were in SAM and did not mark any specimen in SAM as the holotype, I consider this not to be a valid lectotype designation under Article 74.5 (ICZN 1999). To preserve the stability of nomenclature, I hereby designate the male specimen in SAM bearing Lea's 'TYPE' label and the registration number I.15470 (Fig. 3) as the lectotype and have labelled it as such. The male 'paratype' in SAM referred to by Britton (1978) becomes a paralectotype, although it has not been located (P. Hudson pers. comm.).

Jarvis (1927) considered, incorrectly, *L. trichosterna* a synonym of *Lepidiota grata* Blackburn, 1890 but curiously continued to use the junior name. *Lepidiota grata* also damages sugarcane at Gin Gin (Allsopp *et al.* 1993), the type locality of *L. trichosterna*, so Jarvis presumably confused the two species.

Diagnosis (Figs 1-3). Body 20-25 mm long, bright reddish brown. Anterior face of clypeus with a narrow, smooth, bare area in middle; upper surface coarsely but uniformly punctured or with small unpunctured area in middle, each puncture with an elongate, short, adpressed white seta about as long as the puncture, anterior margin very slightly indented in middle. Frons similarly but more irregularly punctured, punctures with a seta as on clypeus or with a longer, finer, forwardly directed seta towards posterior angles. Terminal segment of maxillary palp with small depression on dorsal-outer surface, length 3x width. Antenna with segment 8 1.5 mm long in males, 0.5 mm long in females. Pronotal length 1.4x width, sides obtusely angulate in middle, anterior and posterior angles sharp, slightly obtuse; without defined anterior or posterior margins; surface coarsely and irregularly punctured (20 mm^{-2}) near middle of base, with narrow, unpunctured, midlongitudinal line, each puncture with an elongate, pointed white seta 1-2 times as long as puncture; without long, erect setae. Scutellum more densely clothed with elongate, white setae. Elytra with narrow intervals 1, 3 and 5 very slightly convex, surface except intervals 3 and 5 sparsely and uniformly clothed with elongate, white setae (< 25 mm^{-2}) that arise from fine punctures. Propygidium densely clothed with fine, adpressed setae (140 mm^{-2}). Pygidium clothed similarly to elytra with fine, shorter, adpressed setae (35 mm^{-2}). Pronotal hypomera with long, fine, yellow setae, with white, flattened setae admixed on anterior half; ventral thorax densely clothed with long, fine, yellowish setae. Legs and abdominal ventrites clothed with long, fine setae and a few white, flattened setae on anterior ventrites, long setae becoming sparser and shorter and flattened setae becoming denser on posterior ventrites. Aedeagus almost triangular from above (Fig. 4).

Larvae have raster of two, single, parallel rows, each with 10-20 pali (Allsopp *et al.* 1993, fig. 4, Miller and Allsopp 2000, fig. 34, Sallam *et al.* 2007, fig. 11.13a).

Distribution. Occurs from Rockhampton and Gladstone in Queensland south to the northeastern Darling Downs and northeastern New South Wales (Britton 1978, Allsopp 1990, Allsopp *et al.* 1993, Miller and Allsopp 2000, ANIC, QDAF, QM, UQIC; Fig. 19) in forest loam and sandy soils (Cherry and Allsopp 1991, Allsopp *et al.* 1993).

QM has one specimen labelled as from Stanthorpe and part of the Sutton collection – Edmund 'Ned' Sutton lived near Stanthorpe and labelled many of his specimens with his locality rather than from where they came (G.B. Monteith pers. comm. 2018). WAIC has a specimen labelled as from Babinda that is certainly mislabelled (the collector is given as the sugarcane entomologist Richard Bull, who was stationed at Bundaberg and not in northern Queensland). These two localities are not included on Figure 19.

Biology and ecology. Larvae are pests of sugarcane in the Bundaberg and Gin Gin areas of southeastern Queensland (Jarvis 1927, 1929, Allsopp *et al.*1993, 2000, Agnew 1997, Miller and Allsopp 2000, Hunt *et al.* 2002, Sallam *et al.* 2007, Allsopp 2010) and can be found with those of *Antitrogus parvulus* Britton, 1978, *L. negatoria* Blackburn, 1912 and/or *L. noxia* Britton, 1985. Adults have been collected during October-January, typically following rain in November-December (Allsopp *et al.* 1993, Allsopp and Logan 1999) and the species has a 2-year lifecycle (Allsopp *et al.* 1993), with two allochronic populations and damage by larvae apparent in spring or early summer. Adults appear not to feed.

Larval distribution shows no correlation with soil texture (Cherry and Allsopp 1991). Sequential sampling plans for larvae have been devised by Allsopp and Bull (1989). The susceptibility of larvae to chlorpyrifos was discussed by Chandler and Erbacher (1997) and the use of the fungus *Metarhizium anisopliae* to control larvae was discussed by Holdom and Li (1996). Adults are parasitised by the tachinine fly *Palpostoma* sp. (Logan 1999) and larvae were infected with *Heterorhabditis* spp nematodes in a canefield near Bundaberg (Akhurst *et al.* 1992).

Alepida froggatti (Macleay), comb. n.

Froggatt's canegrub

(Figs 7, 11, 21)

Lepidiota froggatti Macleay, 1887: 227; Lea, 1919: 187, adult plate 26, fig. 51; Illingworth and Dodd, 1921: adult plate IX, fig. 5; Britton, 1978: 85, head and pronotum fig. 287B, aedeagus figs 259-260; Allsopp *et al.* 1993: 18, larval raster pattern fig. 11; Miller and Allsopp, 2000: 394, aedeagus fig. 15, larval raster pattern fig. 26; Sallam *et al.* 2007: 328, larval raster pattern fig. 11.13d. Type: Lectotype (here designated), Barron River [as given in original description but Barrior Range and NW Australia on labels], Queensland, in MMUS (Fig. 11).

Type status. Macleay (1887) did not state the number or gender of specimens he saw but he specified that they came from Barron River near Cairns and were collected by Froggatt in 1886. This species is not in the list of type specimens in MMUS (Hahn 1962) or in the list of beetle types transferred on permanent loan from MMUS to ANIC (Britton and Stanbury 1982), although the latter did list types of other species described by Macleay (1887). Britton (1978) referred to a male from 'Barron River, near Cairns' (consistent with locality given in the original description and with the known distribution of the species) in ANIC as the holotype, but the type is not in that collection (my search and C. Lemann and T. Weir pers. comm. 2018) and I suspect Britton did not see the syntype(s). Houston and Weir (1992) were not certain of the status or location of any type specimen, referring to a male as 'holotype (probable)' in '?MMUS'; this was followed by Miller and Allsopp (2000).

Figs 11-16. *Alepida* spp: (11) *Lepidiota froggatti*, lectotype male dorsal, ventral and labels, in MMUS (photographs courtesy of Jude Philip © MMUS); (12) *Lepidiota helleri*, lectotype female dorsal and labels, in ZMB (photographs courtesy of Bernd Jäger, © ZMB); (13-16) *Alepida moorei* **sp. n.**, holotype male in ANIC: (13) dorsal; (14) ventral; (15) aedeagus, dorsal; (16) aedeagus, lateral (photographs by Geoff Thompson © QM).

There are two specimens of *L. froggatti* in MMUS, both with attached labels of 'N.W. Australia' and standing under a label with the locality of 'Barrior Range, NW Aust'; one also has an attached printed label with 'Type' (Fig. 11). In 1888 Macleay described a series of species from northwestern Australia also collected by Froggatt; some of these came from Barrier Range (now Napier Range; Monteith and Rossini 2017). I presume that the labels on the two specimens were added by George Masters, Macleay's curator and then curator of MMUS after 1888 when Macleay gifted his collection to the University of Sydney; Masters is known to have removed and disposed of original labels on specimens and relabelled them (Horning 1988). Presumably, Barron River was inadvertently transcribed as Barrior Range as the species does not occur outside of the wet tropics of northeastern Queensland and the environment at Napier Range is very different. To preserve the stability of nomenclature, I hereby designate the specimen with the label 'Type' (Fig. 11) as the lectotype; the second specimen in MMUS (which has its right fore leg extended forwards) becomes a paralectotype. I have labelled both as such.

Diagnosis (Fig. 11). Body 30-38 mm long, black with a dense clothing of short, recumbent, yellow setae; legs black. Anterior face of clypeus with broad, microreticulate bare area in middle, upper surface uniformly and densely and distinctly punctured, anterior margin with broad V-shaped indentation; anterior margin broadly bilobed. Frons similarly punctured in front, becoming more densely punctured posteriorly, punctures smaller than on clypeus. Terminal segment of maxillary palp elongate-oval, length 3x width. Antenna with segment 8 about 2.2 mm long in males, slightly shorter than segments 2-7 combined. Pronotum strongly transverse, length 1.7x width, widest at base, anterior angles almost square, posterior angles slightly rounded and slightly obtuse; without defined anterior or posterior margins; surface very densely (200 mm^{-2}) and uniformly punctured and setose, anterior margin with sparse fringe of longer, erect, yellowish-brown setae that arise from large punctures, sometimes with a few, long, erect setae arising from middle of disc. Scutellum and elytra similarly densely punctured and setose but without longer setae, surface of elytra with very faint, longitudinal costae representing intervals 1, 3, 5, 7 and 9. Propygidium densely and uniformly setose like elytra in transverse band along posterior margin, the band sharply limited anteriorly along slight ridge about level with spiracle of fifth ventrite, anterior finely setose and microreticulate. Pygidium densely and uniformly setose, setae shorter and thinner than on propygidium. Ventral thorax clothed with long, lighter, semierect setae; posterior femora sparsely clothed with short, recumbent, white setae except for longitudinal, bare, shining area in middle. Abdominal ventrites densely and uniformly clothed with shorter, sparser setae except for small, bare, antero-median areas. Aedeagus evenly tapered to rounded and slightly hooked apices (Fig. 7).

Larvae have a raster of two parallel, single-row palidia each of 13-19 pali with a smaller second inner row in each palidium diverging posteriorly (Allsopp *et al.* 1993, fig. 11, Miller and Allsopp 2000, fig. 26, Sallam *et al.* 2007, fig. 11.13d).

Distribution. Alepida froggatti is confined to the Cooktown-Tully area in or near rainforest (Dodd and Girault 1915, Dodd 1917, Williams 1977, Britton 1978, Allsopp *et al.* 1993, 2000, Agnew 1997, Miller and Allsopp 2000, Sallam *et al.* 2007, ANIC, QM, UQIC; Fig. 21).

There are records in ALA from near Ayr, possibly misidentified *Dermolepida albohirtum* (Waterhouse) and a specimen in UQIC from Ayr that might be mislabelled; Ayr is in the dry tropics and well outside the range and environment of other records. ALA also has a record from Stradbroke Island in QM that is *A. stradbrokensis*. Lea (1919) noted specimens from Coen River that differed in size, colour and clothing of setae but these presumably are some of the specimens used in the description of *L. hylaea*. None of these localities are included on Figure 21.

Biology and ecology. Larvae are minor pests of sugarcane on red volcanic loams close to scrub areas west of Innisfail and around Gordonvale, sometimes in association with *L. caudata* Blackburn, 1890 (Illingworth and Dodd 1921, Allsopp *et al.* 1993, 2000, Sallam *et al.* 2007, Allsopp 2010). Adults have been collected from October to early March, usually after rain, at light and at tide marks (Williams 1977, Britton 1978, Allsopp *et al.* 1993, ANIC, QM, UQIC). Larvae appear to have a 2-year lifecycle (Dodd 1917, Illingworth and Dodd 1921, Allsopp *et al.* 1993, Sallam *et al.* 2007), with damage appearing in spring and early summer.

***Alepida helleri* (Moser), comb. n.**

(Figs 8, 12, 21)

Lepidiota helleri Moser, 1913: 46; Britton, 1978: 86, head and pronotum fig. 287C, aedeagus figs 261-262. Type: Lectotype female (here designated), North Queensland, in ZMB (Fig. 12).

Type status. Moser (1913) described this species from only the female but, as he did not state how many specimens he saw, I assume that syntypes might exist (Recommendation 73F, ICZN). Britton (1978) referred to a female holotype from 'Nord Queensland' in ZMB, presumably the specimen with a circular, red-ringed label with 'Type' (probably added later) but with the locality data 'N Queensland' (Fig. 12). This was followed by Houston and Weir (1992). Neither provided any discussion as to why they considered Moser had only one specimen. For Britton's reference to a holotype to be accepted as a lectotype designation under Article 74.5 (ICZN 1999), Britton must have 'explicitly indicated that he was selecting from the type series that particular specimen to serve as the name-bearing type'. As Britton provided no discussion, did not label any specimen in ZMB and did not correctly state

the collection data on the specimen label, I consider that Britton's mention of a holotype does not constitute a valid lectotype designation. I hereby designate the specimen in ZMB (Fig. 12) the lectotype in order to preserve the stability of nomenclature and have labelled it as such.

Diagnosis (Fig. 12). Body 23-34 mm long, dark reddish brown; ventrite 6, apical half of ventrite 5, apical margin of the propygidium and lateral margins of the pygidium darker yellowish brown. Anterior face of clypeus with bare median third; upper surface densely punctured, more so in the middle, most punctures with a very short, pointed, semi-erect, yellowish seta; anterior margin slightly indented in middle. Frons densely and finely punctured, most punctures with a short, finely pointed, semi-erect, yellowish seta, in addition long, erect, brown setae arising from larger punctures. Terminal segment of maxillary palp slender, fusiform, length 3.3x width, with an elongate, elliptical, depression on upper side. Antenna with segment 8 2.25 mm long in males, slightly longer than segments 2-7 combined, in females 1.9 mm long. Pronotal length 1.8-1.9x width, widest at about two-thirds length then indented slightly before posterior angles, anterior angles slightly obtuse, posterior angles almost square and rounded; anterior margin with trace of a narrow, raised margin towards anterior angles; surface densely and uniformly punctured as on frons, punctures with similar but more recumbent setae; in addition anterior margin and disc with very long, backwardly directed, brownish setae that each arise from a larger puncture (may be effaced). Scutellum densely punctured and clothed with similar short setae. Elytral densely and uniformly punctured and with short setae like pronotum; in addition, scattered, long, brown, semierect setae on sutural interval and base of elytra around the scutellum, and secondary, less dense, fine, darker, larger punctures. Propygidium finely, densely and uniformly punctured over all surface. Pygidium with punctures larger than on propygidium, setae short, semierect and uniform. Ventral surface of thorax and coxae densely clothed with long, fine, brown setae; legs with sparse, long, yellowish setae. Abdominal ventrites very densely setose at the sides, with very sparse setae in the middle. Aedeagus broad in lateral view, apices indented (Fig. 8).

Distribution. Known from the Atherton Tableland and nearby ranges in northeastern Queensland in rainforest (Britton 1978, ANIC, QM, UQIC; Fig. 21).

Biology and ecology. Adults have been collected at light during October-January (Britton 1978, QM).

Alepida hylaea (Britton), comb. n.

(Figs 9, 22, 23)

Lepidiota hylaea Britton, 1978: 87, head and pronotum fig. 287D, aedeagus figs 263-264. Type: Holotype male (by original designation), Coen River, Queensland, in SAM.

Diagnosis (Fig. 23). Body 25-34 mm long, dark reddish brown, with a dense clothing of short, adpressed setae giving it a greyish, powdered appearance; legs bright reddish brown. Anterior face of clypeus with a shallow concavity; upper surface densely and uniformly punctured, each puncture with a semi-erect, short, fine seta, setae extending across mid line; anterior margin slightly indented in middle with broad, rounded lobes. Frons similarly puncture and setose in front, becoming more densely punctured about the middle and posteriorly, posterior setae finer. Terminal segment of maxillary palp ovoid, pointed, length 2.5x width, with a large, flat area on upper side. Antenna with segment 8 2.6 mm long in males, longer than segments 2-7 combined; lamella 8 1.8 mm long in females. Pronotal length 1.65x width, widest at about two-thirds of length, anterior and posterior angles slightly obtuse; anterior and posterior margins not raised or defined by a groove; surface very densely and uniformly punctured, each puncture with a short, adpressed, finely pointed, yellow-white seta; anterior margin with scattered long, erect, yellowish setae. Scutellum, elytra and propygidium similarly punctured and setose as disc of pronotum; elytra with traces of longitudinal costae representing intervals 3, 5, 7 and 9. Propygidium and pygidium clothed with dense, finer and shorter setae. Ventral surface of thorax clothed with adpressed setae, slightly longer than the long setae on the pronotum; legs with whitish setae similar to those on pronotum. Abdominal ventrites punctured and clothed with setae as on pygidium, except glabrous area on anterior margins of ventrites 2-5. Aedeagus with parameres constricted before widening at rounded apices (Fig. 9).

Distribution. Known from near Coen and near Dulhunty River Crossing and at Captain Billy Landing on the northern part of Cape York Peninsula (Britton 1978, ANIC, QDAF; UQIC; Fig. 22).

Biology and ecology. Adults have been collected during September (Britton 1978, UQIC).

***Alepida moorei* sp. n.**

(Figs 13-16, 19)

Types. Holotype ♂, AUSTRALIA (QUEENSLAND): 1:100,000, 56JKQ916391, Dunmore SF [State Forest] SQ [southern Queensland], 9.xii.[19]99 Watkins, 99:392 mv light, elev.: 350 m / S.G. Watkins Collection Donated 2001 / aedeagus dissected out and mounted on separate card with number 99:392, in ANIC, database accession number 25-064230 (Fig. 13). *Paratypes*: 31 ♂♂, same data as holotype and aedeagi dissected out, but with serial numbers 99:367-99:391 and 99:393-398, in ANIC; 1 ♂, 150°58' east, 27°38' south, Dunmore SF [State Forest], SQ 26.xii.1998, 98:909 mv light, S Watkins col / S.G. Watkins Collection Donated 2001 / aedeagus dissected out and mounted on separate card with number 98:909, in QM.

Description. Male (Figs 13-16). Body 23-25 mm long, dark reddish brown, pronotum often with darker irregular patches. Anterior face of clypeus with setae scattered across entire width; upper surface coarsely but punctured but

with fewer punctures in middle of posterior, each puncture with an elongate, short, adpressed white seta slightly longer than the puncture, anterior margin very slightly indented in middle. Frons similarly but more irregularly punctured, fewer punctures in middle posterior, each puncture with longer, finer forwardly directed seta than on clypeus; a few long setae above each eye. Terminal segment of maxillary palp with large depression on dorsal-outer surface, length 3x width. Antenna 9-segmented, segment 4 slightly constricted at half length as if composed of two fused segments, segment 7-9 1.9 mm long. Pronotal length 2.1x width, sides obtusely angulate at about two-thirds length, anterior and posterior angles sharp, anterior ones obtuse, posterior ones slightly obtuse; without defined anterior or posterior margins; surface coarsely and irregularly punctured (less so than in *A. crinita*) but with vague, narrow, unpunctured, midlongitudinal line, each puncture with an elongate, pointed white seta 1-2x as long as puncture width; with a few longer setae near anterior angles behind each eye. Scutellum more densely clothed with shorter, elongate, white setae. Elytra with narrow intervals 1, 3 and 5 very slightly convex, surface except intervals 3 and 5 sparsely and uniformly clothed with elongate, white setae that arise from fine punctures. Propygidium densely clothed with fine, adpressed setae. Pygidium clothed similarly to elytra with finer, shorter, adpressed setae. Pronotal hypomera with long, fine, yellow setae, with white, flattened setae admixed on anterior half; ventral thorax densely clothed with long, fine, yellowish setae. Legs and abdominal ventrites clothed with long, fine setae becoming sparser and shorter and flattened setae becoming denser on posterior ventrites; a few longer setae on posterior margin of last segment. Aedeagus broadly triangular from above, tapering towards apex but with apices rounded, in profile with apex rounded and constricted just behind apex (Figs 15-16), surface with scattered punctures with very short setae.

Female. Unknown.

Diagnosis. Closely related to *A. crinita* but with the antennae 9-segmented, the dorsal surface dark reddish brown with darker patches on the pronotum and with the parameres wider towards the apex.

Etymology. This species is dedicated to the memory of the late Barry Philip Moore (1925-2015), who gave his time and encouragement to a young coleopterist 45 years ago.

Distribution. Known only from the type locality (Fig. 19); this is about 15 km southwest of Cecil Plains and further southwest of the distribution of *A. crinita*. It is in an area of the Blythsdale Braystones soil formation of grey fine sands and sandy loams, quite distinct from the heavy black cracking clays to the east (Anon. 1952).

Biology and ecology. Adult males were collected at light in December.

Alepida picticollis (Lea), comb. n.

Picticollis canegrub

(Figs 5, 17, 20)

Lepidiota picticollis Lea, 1916: 291; Britton, 1978: 83, head and pronotum fig. 286E, aedeagus figs 253-254; Allsopp *et al*. 1993: 26, larval raster pattern fig. 10; Miller and Allsopp 2000: 401, aedeagus fig. 27, larval raster pattern fig. 27; Sallam *et al*. 2007: 331, larval raster pattern fig. 11.13k. Type: Holotype male (by original designation), Stradbroke I., Queensland, in SAM Type I.4525 (Fig. 17).

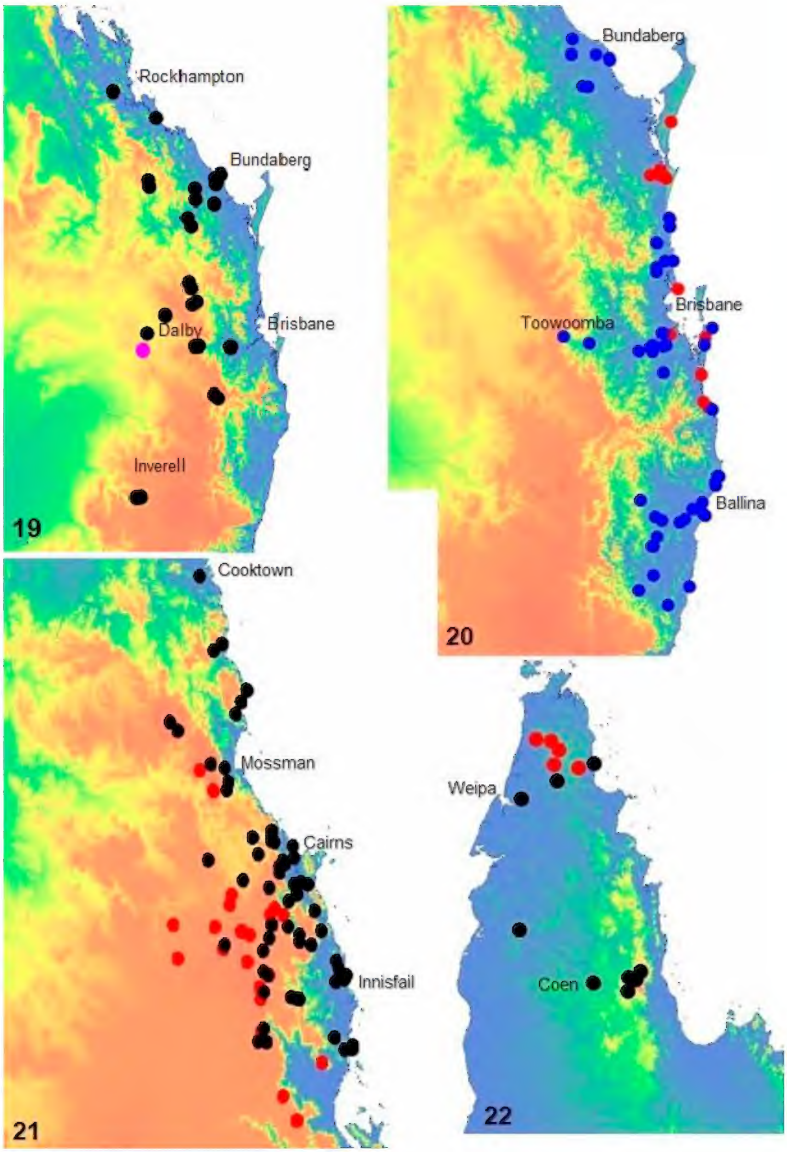
Type status. Lea (1916) saw more than one specimen 'The specimen from Mr. Carter ... is considerably larger than the others ...', but in that paper he unequivocally designated a 'Type' with the SAM registration number 'I.4525' – this is the male specimen marked as such in SAM (Fig. 17) and must be considered the holotype (Article 73.1.1, ICZN 1999). This is also presumably the specimen considered as the holotype by Britton (1978) and is the one noted as the holotype by Houston and Weir (1992) and Miller and Allsopp (2000). A second male specimen with the same data as the holotype mentioned by Britton (1978) is a paratype and it is likely that there is at least one more specimen in another collection.

Diagnosis (Fig. 17). Body 25-35 mm long; head black; pronotum black, with a trace of two large, central, reddish-yellow areas on each side of black midlongitudinal area; scutellum dark reddish brown to black; elytra yellowish or reddish brown, sometimes with the sutural and lateral margins darker; abdomen, ventral surface and legs dark reddish brown; setae of dorsum white. Anterior face of clypeus with wide, smooth, bare area in middle; upper surface more densely and finely punctured in middle than at sides, each puncture with a fine, recumbent seta, anterior margin slightly indented. Frons densely and finely punctured, each puncture with a fine, recumbent seta. Terminal segment of maxillary palp with large, shallow, concave, elliptical, dull-surfaced area on dorsal side, length 3.6x width. Antenna with segment 8 2.3 mm long in males. Pronotal length 1.65x width, widest at posterior angles, anterior angles slightly obtuse, posterior angles almost square; anterior and posterior margins not raised or defined by a groove; surface with black areas more densely punctured than paler areas, each puncture with a short, fine, backwardly-directed, elongate seta that is flattened; without long, erect setae. Scutellum densely clothed with similar setae. Elytral intervals 2, 4, 6, 8 and 10 irregularly punctured, each puncture with a seta similar to those on pronotum. Propygidium with finer, yellowish setae anteriorly, posterior with whiter, longer, more flattened setae similar to those on pygidium. Pygidium densely and uniformly punctured, with flattened white setae. Ventral surface of thorax densely clothed with long, whitish setae; legs with similar setae. Abdominal ventrites sparsely clothed with recumbent, white setae. Aedeagus with parameres tapering before widening slightly at rounded apices (Fig. 5).

Figs 17-18. *Alepida* spp: (17) *Lepidiota picticollis*, holotype male lateral and labels, in SAM (photographs by Eleanor Adams, © South Australian Museum Board 2018); (18) *Lepidiota stradbrokensis*, holotype male dorsal and labels, in QM (photograph © Greg Daniels).

Larvae have a raster of two rows of palidia diverging posteriorly and each with a shorter row of pali posteriorly; there are 19-38 pali in each palidium (Allsopp *et al.* 1993, fig. 10, Miller and Allsopp 2000, fig. 27).

Distribution. Known from just north of Bundaberg south to Grafton, New South Wales in coastal areas (Britton 1978, Allsopp 1990, Allsopp *et al.* 1993, Miller and Allsopp 2000, ANIC, QM, UQIC; Fig. 20). ALA has an incorrect latitude record for a specimen from Busbys Flat, New South Wales, that places it in the Sydney area and a record in packaged food from Mt Gambier, South Australia; these are not included on Fig. 20.



Figs 19-22. Distribution of *Alepida* spp: (19) *A. crinita* (black dots) and *A. moorei* **sp. n.** (pink dot) in southeastern Queensland; (20) *A. picticollis* (blue dots) and *A. stradbrokensis* (red dots) in southeastern Queensland and northeastern New South Wales; (21) *A. froggatti* (black dots) and *A. helleri* (red dots) in northeastern Queensland; (22) *A. hylaea* (black dots) and *A. ultima* (red dots) on Cape York Peninsula. Background colours on the maps indicate elevation.

Biology and ecology. Larvae have damaged sugarcane on very sandy soils at Yandaran, Elliott Heads and Kolan in the Bundaberg area and in the Isis area at Logging Creek and Goodwood (Bull 1986a, Allsopp *et al.* 1993, 2000, Agnew 1997, Miller and Allsopp 2000, Hunt *et al.* 2002, Sallam *et al.* 2007, Allsopp 2010). This species has a 2-year lifecycle, with adults usually emerging in September-October following storm rain but some can emerge later in summer or even autumn (Allsopp *et al.* 1993, Sallam *et al.* 2007). Larval damage is apparent in late summer and early autumn (Bull 1986a, Allsopp *et al.* 1993, Sallam *et al.* 2007).

Males are attracted to virgin females, suggesting a pheromone is involved in mate recognition (Allsopp 1993). The major components of the cuticular hydrocarbons from adult females are tricosane (9%), 3-methyltricosane (27%), 9-tricosene (16%) and 9,10-tricosadiene (Fletcher *et al.* 2001, 2008). Sequential sampling plans for larvae have been devised by Allsopp and Bull (1989). The susceptibility of larvae to chlorpyrifos was discussed by Chandler and Erbacher (1997) and larvae were controlled with a controlled-release formulation of chlorpyrifos for 2 years after application (Bull 1986a, 1986b, Allsopp *et al.* 1995). Milner *et al.* (2002) showed that an isolate of the fungus *Metarhizium anisopliae* could kill 85% of larvae in laboratory tests and larvae were infected with *Heterorhabditis* spp nematodes in a cane field near Bundaberg (Akhurst *et al.* 1992).

Alepida stradbrokensis (Lea), comb. n.

(Figs 6, 18, 20)

Lepidiota froggatti var. *stradbrokensis* Lea, 1919: 187, holotype plate 26, fig. 52; Britton, 1978: 84, head and pronotum fig. 287A, aedeagus figs 257-258. Type: Holotype male (by monotypy), Stradbroke Island, Queensland, in QM (Fig. 18).

Lepidiota stradbrokensis: Britton, 1978: 84.

Type status. Lea saw only one specimen ('A specimen from Stradbroke Island ...') – this is the specimen in QM and is the holotype by monotypy (Article 73.1.2, ICZN 1999) (Fig. 18). This is presumably the specimen that Britton (1978) and Houston and Weir (1992) considered the holotype.

Diagnosis (Fig. 18). Body 24-26 mm long, dark reddish brown, but with a dense clothing of short setae giving it a greyish, powdered appearance; legs very dark brown. Anterior face of clypeus with scattered setae across middle; upper surface densely and finely punctured, each puncture with a semi-erect, short, yellowish seta, setae inclined outwards from the mid line; anterior margin slightly indented. Frons densely and finely punctured, each puncture with a short, finely pointed, yellowish seta. Terminal segment of maxillary palp slender, fusiform, length 3.3x width, with an elongate, elliptical, depression on upper side. Antenna with segment 8 1.9 mm long in males, slightly longer than segments 2-7 combined. Pronotal length 1.65x width, widest at about mid point and narrowing posteriorly only slightly, anterior

angles obtuse, posterior angles almost square; anterior and posterior margins not raised or defined by a groove; surface densely and uniformly punctured as on frons, punctures with similar but more recumbent setae; without long, erect setae; each side with a small, rounded, bare area at about mid length. Scutellum densely punctured and clothed with similar setae. Elytral with traces of longitudinal costae representing intervals 3, 5 and 7, with a distinct tubercle at posterior junction of 3 and 5; densely and uniformly punctured and setose like pronotum. Propygidium with similar setae on posterior half, anterior half with shorter setae. Pygidium with posterior margin smooth and unpunctured, surface otherwise densely punctured and setose, surface dull with strong, reticulate microsculpture. Pygidium densely and uniformly punctured and setose. Ventral surface of thorax and coxae densely clothed with long, yellowish-brown setae; ventral face of posterior femur uniformly clothed with long, pale, recumbent setae. Abdominal ventrites punctured and setose like elytra but setae longer and whiter. Aedeagus with parameres tapering to about half length before slightly widening to rounded apices (Fig. 6).

Distribution. Known from coastal areas from Fraser Island and Tin Can Bay to Tugun (Britton 1978, QM, UQIC; Fig. 20).

Biology and ecology. Adults have been collected during August-October (Britton 1978, QM, UQIC).

***Alepida ultima* (Britton), comb. n.**

(Figs 10, 22, 24)

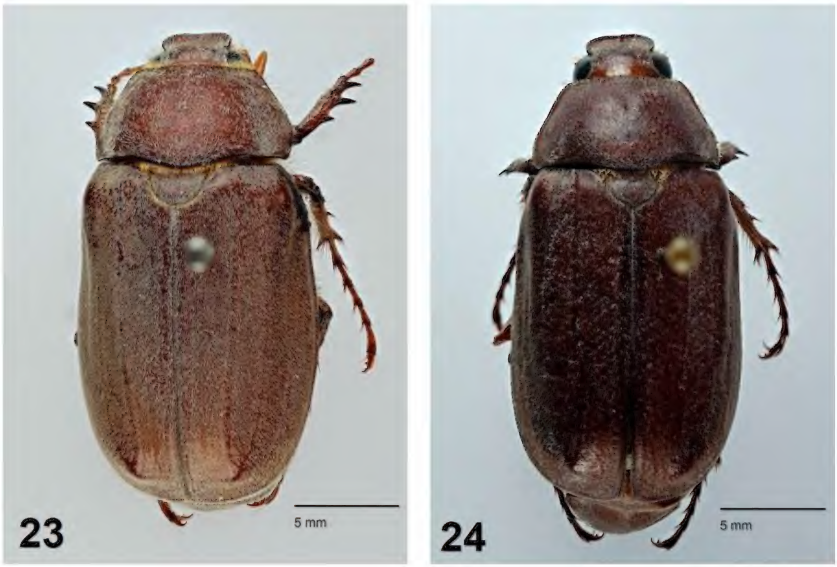
Lepidiota ultima Britton, 1978: 87 head and pronotum fig. 287E, aedeagus figs 265-266. Type: Holotype male (by original designation), Cape York, Queensland, in AM.

Diagnosis (Fig. 24). Body 24 mm long; body and legs reddish brown with white dorsal pubescence. Anterior face of clypeus with wide, smooth, bare area in middle, setose at sides; upper surface densely and finely punctured, each puncture with a semi-erect, short, white seta, setae inclined outwards at 45° from the mid line; anterior margin slightly indented. Frons densely punctured, each puncture with a short, finely pointed, white seta, setae generally inclined backwards. Terminal segment of maxillary palp slender, fusiform, length 2.5x width, with a large elongate, elliptical, depression covering most of upper side. Antenna with segment 8 2.3 mm long in males, slightly longer than segments 2-7 combined. Pronotal length 1.7x width, widest at about two-thirds length, anterior and posterior angles obtuse, posterior angles rounded; anterior and posterior margins not raised or defined by a groove; surface densely and uniformly punctured as on frons, punctures with similar but slightly thinner and more recumbent setae; with scattered long, erect setae on anterior margin and in anterior angles. Scutellum densely costae representing intervals 3, 5, 7 and 9; densely and uniformly punctured

and clothed with similar setae. Elytra with traces of longitudinal and setose like pronotum. Propygidium and pygidium with surface densely punctured and setose, surface dull, setae shorter and finer than on elytra. Ventral surface of thorax and coxae densely clothed with long, yellowish-brown setae; ventral face of posterior femur uniformly clothed with long, paler setae. Abdominal ventrites punctured and setose like elytra, setae shorter, finer and more yellowish than on elytra, except glabrous area on anterior margins of ventrites 2-5. Aedeagus with parameres smoothly tapered to about halfway, apices rounded (Fig. 10).

Distribution. Known from the northern part of Cape York Peninsula near Heathlands (Britton 1978, ANIC; Fig. 22).

Biology and ecology. Adults have been collected in malaise traps and at light in September-December (ANIC).



Figs 23-24. *Alepida* spp: (22) *A. hylaea*, paratype male dorsal; (23) *A. ultima*, male dorsal (photographs by Greg Daniels, © Greg Daniels).

Key to species of *Alepida*

1 Elytra with sparse (< 25 mm^{-2}), adpressed, elliptical or finely tapered white, flattened setae; elytra bright, shining reddish brown or brown; SE Queensland and NE New South Wales 2

– Elytra with dense (> 60 mm^{-2}) semierect or recumbent, sharply pointed, white or yellowish setae; elytra reddish brown to dark brown or black but appearing dull yellowish because of the dense clothing of setae … 4

2(1) Body 25-32 mm long; flattened setae on the dorsal surface elongate, tapered to a fine point (Fig. 17); head black, pronotum dark brown or black, often with a reddish area on each side of the middle, elytra light to dark reddish brown (Fig. 17); aedeagus Fig. 5; SE Queensland and NE New South Wales (Fig. 20) …….. *picticollis* (Lea)

– Body 20-25 mm long; flattened setae on the dorsal surface parallel-sided or elongate-elliptical (Figs 1-3, 13); pronotum uniformly light reddish brown to brown, sometimes with darker irregular patches …... 3

3(2) Antennae 10-segmented; body bright reddish brown (Figs 1-3); aedeagus Fig. 4; SE Queensland and NE New South Wales (Fig. 19) … ……... *crinita* (Brenske)

– Antennae 9-segmented; body dark reddish brown (Figs 13-14); aedeagus Figs 15-16; inland SE Queensland (Fig. 19) ..... *moorei* **sp. n.**

4(1) Anterior margin of pronotum without erect setae (Fig. 18); body 24-26 mm long; aedeagus Fig. 6; SE Queensland (Fig. 20) ……. ……. *stradbrokensis* (Lea)

– Anterior margin of pronotum with long, erect or semierect setae; body 28-38 mm long; northern Queensland ……... 5

5(4) Legs black (Fig. 11); ventral face of posterior femora with a large, bare, unpunctured and shining area in the middle (Fig. 11); propygidium with a transverse band of short, pale, recumbent setae on the posterior margin, sharply defined anteriorly by a bare, shallow, transverse depression; aedeagus Fig. 7; NE Queensland (Fig. 21) …..... ……..... *froggatti* (Macleay)

– Legs reddish or yellowish brown; ventral face of posterior femora with or without a bare unpunctured area in the middle; propygidium without a transverse band of setae defined by a bare depression ……... 6

6(5) Disc of pronotum and sutural and basal areas of elytra with very fine, longer, yellowish setae in addition to short setae (Fig. 12); femora, tibiae and tarsi pale yellowish brown, with black apices; aedeagus Fig. 8; highlands of NE Queensland (Fig. 21) ……... *helleri* (Moser)

– Disc of pronotum and surface of elytra without long, erect setae, only with short setae; legs all reddish brown ……. 7

7(6) Posterior angles of pronotum less rounded (Fig. 23); anterior edge of clypeus with a shallow concavity; body 25-34 mm long; aedeagus Fig. 9; mid to northern Cape York Peninsula (Fig. 22) ……. *hylaea* (Britton)

– Posterior angles of pronotum more rounded (Fig. 24); anterior edge of clypeus almost straight in the middle; body about 24 mm long; aedeagus Fig. 10; northern Cape York Peninsula (Fig. 22) …… ……..... *ultima* (Britton)

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GENERIC LIMITS OF *PHENOLIA* ERICHSON (COLEOPTERA: NITIDULIDAE: NITIDULINAE)

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Abstract

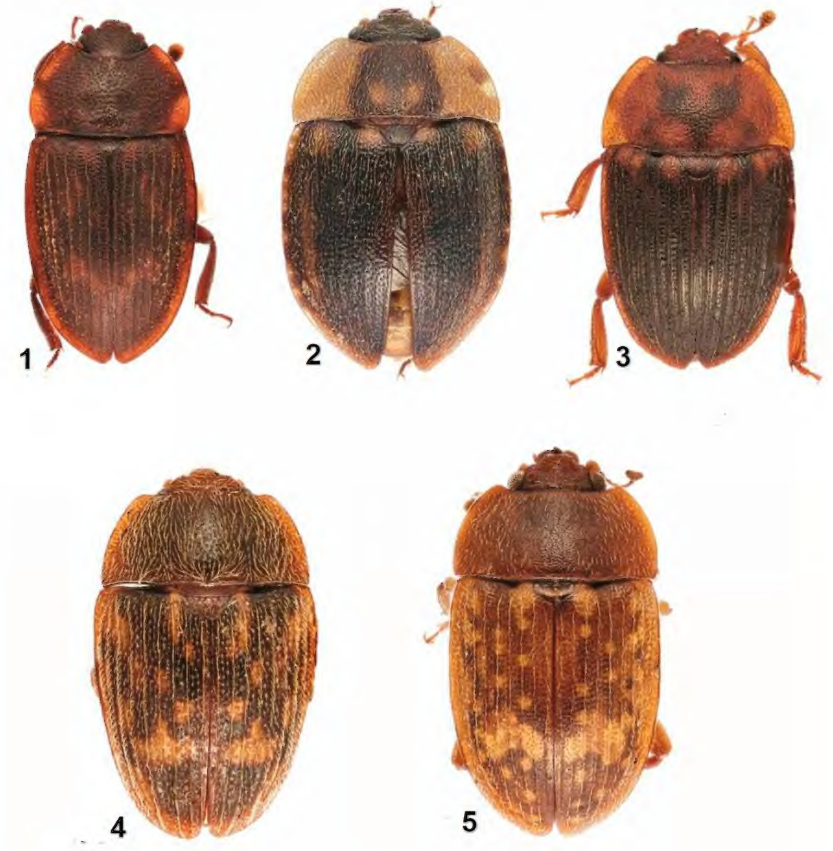
Adult and larval evidence is given for removing the Old World subgenera *Aethinodes* Blackburn, *Lasiodites* Jelínek and *Plesiothina* Kirejtshuk from the North American genus *Phenolia* Erichson and considering each of them a separate genus.

Introduction

The genera *Aethinodes* Blackburn, *Lasiodites* Jelínek and *Plesiothina* Kirejtshuk, all of which occur in Australia, were considered to be subgenera of *Phenolia* Erichson by Kirejtshuk and Kvamme (2002). In the present study, this conclusion is critically reviewed.

Phenolia was described by Erichson (1843) based on a single species, *Nitidula grossa* Fabricius, 1801, occurring in eastern North America (Fig. 1). *Aethinodes* Blackburn (1891) is an endemic Australian genus apparently related to a suite of Old World species placed until recently in the genus *Lasiodactylus* Perty (Figs 3-4). The genus *Plesiothina* was described by Kirejtshuk (1990) based on an Indonesian species, *P. acutula* Kirejtshuk, but also containing the Australian *P. ampla* Kirejtshuk, 2006 (Fig. 2). Kirejtshuk and Lawrence (1999) noted that the name *Lasiodactylus*, which had been used for a number of Old World fruit-eating Nitidulinae, was synonymous with *Lordites* Erichson and should be restricted to a few Neotropical species only. Jelínek (1999) proposed a new generic name *Lasiodites* (type species *Nitidula picta* Macleay, 1825, Fig. 5) for these Old World species and considered them closely related to members of the genus *Aethinodes*. He also mentioned an external similarity with the genus *Phenolia* but noted that this Nearctic genus differed from *Lasiodites* in several respects. Kirejtshuk and Kvamme (2002: 3-4) criticized Jelínek for not providing evidence in support of his interpretation, stating that Jelínek did not regard 'the overall similarity of *Lasiodites* and *Phenolia* as a result of close relationship'. These authors did not specifically mention any of the characters Jelínek used to distinguish *Phenolia* from the *Lasiodites* group but they did include details of character variation among the 27 *Lasiodites* species occurring mainly in Africa and Madagascar, indicating that at least some of Jelínek's characters were variable within that genus. They went on to treat *Lasiodites* and *Aethinodes*, plus the genus *Plesiothina*, as subgenera of *Phenolia* and this has been followed in various general works (Jelínek and Audisio 2007, Cline *et al.* 2014). Although characters were given for the subgenera and for those genera considered to be in the same "complex", the characters distinguishing the newly expanded genus *Phenolia* were never mentioned. It must be stressed

here that, although informal generic complexes might be useful as tools for segregating genera in a large subfamily like Nitidulinae, they have no phylogenetic significance, whereas the inclusion of several genera as subgenera within a genus with an older name represents a phylogenetic hypothesis and, as such, requires more supporting data than were present in the work by Kirejtshuk and Kvamme (2002).



Figs 1-5. Nitidulinae adults, dorsal: (1) *Phenolia grossa* (Fabricius), length = 7.7 mm; (2) *Plesiothina ampla* Kirejtshuk, length = 4.3 mm; (3) *Aethinodes attenuata* (Reitter), length = 5.0 mm; (4) *Aethinodes marmorata* Blackburn, length = 3.0 mm; (5) *Lasiodites picta* (Macleay), length = 6.2 mm.

Adult morphology

Of those adult features used by Jelínek to distinguish *Phenolia grossa* from both *Aethinodes* and *Lasiodites*, some appear to vary at least within *Lasiodites*, while all of them have been questioned by Kirejtshuk (*in litt*.).

The following differences include most of those used by Jelínek and are based on my own observations of all *Aethinodes* species, *Plesiothina ampla* Kirejtshuk, *Lasiodites picta* (Macleay) and a few other species of *Lasiodites* from Africa and Asia. None of them was discussed by Kirejtshuk and Kvamme (2002).

1. Labrum in *Phenolia* shallowly emarginate, while those in the other three genera are more deeply emarginate, usually with a narrow incision at the middle.

2. Mandibular apex in *Phenolia* bidentate, while in the *Aethinodes* group it is unidentate, with a smaller subapical tooth.

3. Prosternal process in the *Aethinodes* group more strongly curved apically, whereas that in *Phenolia* is barely curved.

4. Lateral subapical angles of prosternal process in *Phenolia* acute and strongly projecting laterally. Although lateral expansions of this process occur in all members of the *Aethinodes* group, their apices are not acute.

5. Mesoventrite coarsely punctate in *Phenolia* but impunctate in members of the *Aethinodes* group.

6. Mesoventrite without a median carina in *Phenolia* but with at least a weak carina in members of the *Aethinodes* group.

7. Each pronotal hypomeron in *Phenolia* with what appears to be a stridulatory file extending laterally from the outer corners of the procoxa (Fig. 14). This feature is present in both sexes but it is not known if it is a sound-producing organ.

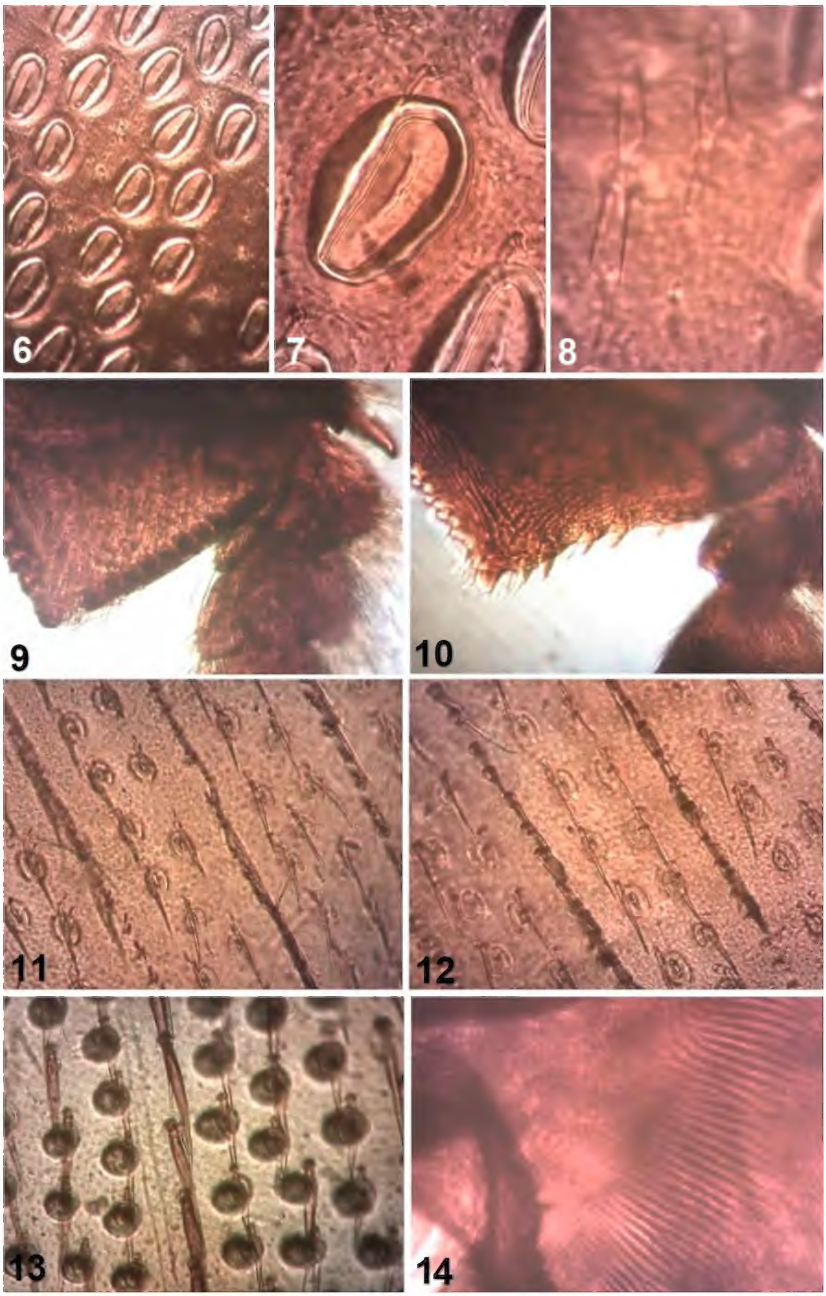
8. Ratio of temple length to eye length in *Phenolia* about 0.7, as compared with 0.5 or less in members of the *Aethinodes* group.

9. Explanate elytral margins in *Phenolia* extend almost to elytral apices; in the *Aethinodes* group they are either absent or end well before the elytral apices.

10. Pronotum widest at about middle in *Phenolia* but near posterior end in members of the *Aethinodes* group.

11. Vertexal line absent in *Phenolia* but complete in the *Aethinodes* group.

12. Protibial apex in males and females of *Phenolia* with a few short, well separated, light coloured, acute spines (Fig. 10) but in males of the *Aethinodes* group with a continuous row of short, dark, blunt spines (Fig. 9). This row of spines in the latter group forms a solid carina, which might be involved in copulation, perhaps as a holdfast; it also occurs in the genera *Gaulodes* Erichson, *Australaethina* Kirejtshuk & Lawrence and some other nitiduline genera.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13. Frst abdominal ventrite without postcoxal lines in *Phenolia* but with postcoxal lines in all members of the *Aethinodes* group.

14. All taxa considered here have a similar type of dual elytral punctation and vestiture, with longer, thicker setae forming dense, longitudinal rows and shorter, finer setae lying in between the rows, with each arising adjacent to a shallow pit (Figs 6, 11-13); this condition with some variation also occurs in many other nitiduline genera, such as *Australaethina* Kirejtshuk & Lawrence, *Australycra* Kirejtshuk & Lawrence, *Physoronia* Reitter, *Pocadites* Reitter, *Rixerodes* Kirejtshuk & Lawrence and *Stelidota* Erichson. The following details, however, are quite different in *Phenolia grossa* from the situation in *Aethinodes*, *Lasiodites* or *Plesiothina*: (1) the rows of macrosetae in *Phenolia* (Fig. 6) are somewhat irregular or incomplete, so that the pits and microsetae alternating with macrosetal rows vary considerably, while in the *Aethinodes* group the rows of macrosetae are more even and alternate with two or three rows of pits and microsetae; (2) macrosetae in the *Aethinodes* group are well pigmented, more or less gradually thickened in the middle and acute at the apex (Figs 11-13), while those in *Phenolia* (Fig. 8) are pale, gradually expanded to about middle, then irregularly narrowed to form a curved acute apex; (3) elytral pits in *Phenolia* (Figs 6-7) are large and elongate-oval with a thick margin and a longitudinal elevation in the middle, quite different from the smaller, circular to slightly ovate pits in the *Aethinodes* group (Figs 11-13).

Jelínek (1999) certainly recognised that his new genus *Lasiodites* appeared to be related to *Aethinodes* (he might have been unaware of *Plesiothina*) but he felt, as I do, that there was not sufficient evidence to assume that the New World *Phenolia grossa* (Fabricius) was so closely related to the group of Old World genera that they should be placed in the same genus.

Larval biology and morphology

An obvious biological difference between the two groups concerns feeding habits. *Phenolia grossa* is a fungivore with a specific host, *Laetiporus sulphureus* (Bull.) Murrill (Polyporaceae) (Böving and Rozen 1962), while the species of *Aethinodes* and *Lasiodites* are primarily saprophagous, feeding on decaying vegetable material, especially fruits.

Figs 6-14. Nitidulinae adults: (6-8) *Phenolia grossa* (Fabricius): (6) portion of elytron showing asymmetrically aligned pits and two short rows of abraded macrosetae; (7) portion of elytron showing a large pit and associated microseta; (8) portion of elytron showing three macrosetae. (9-10) protibial apex of male: (9) *Lasiodites picta* (Macleay) with continuous row of blunt, dark spines; (10) *Phenolia grossa* with well-separated acute, light spines. (11-13) portion of elytron, showing rows of macrosetae and pits: (11) *Lasiodites picta* (Macleay); (12) *Aethinodes attenuata* (Reitter); (13) *Plesiothina ampla* Kirejtshuk. (14) *Phenolia grossa* (Fabricius), left prothoracic hypomeron showing possible stridulatory file.

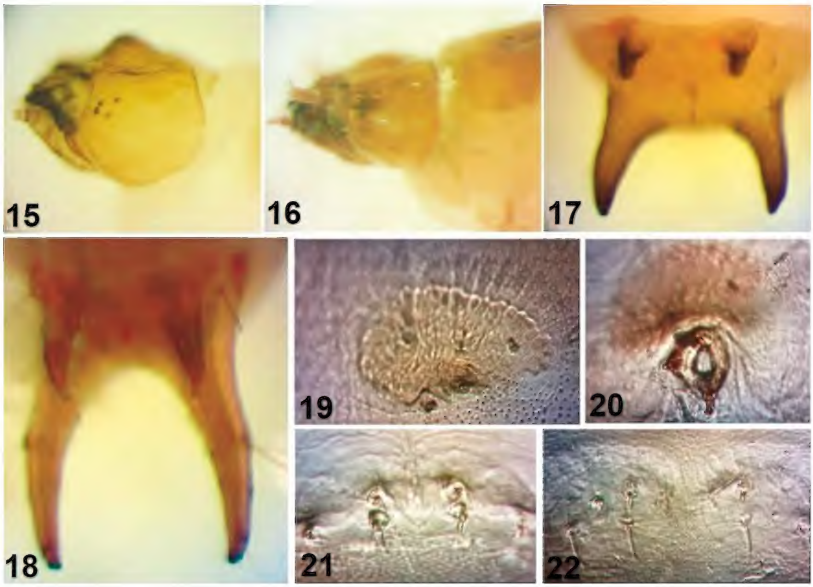
Sufficient larvae have been found in the ANIC to add a few comparisons based on immature forms. The following larvae have been examined:

Phenolia grossa (Fabricius). Several specimens from Dorset, Bennington Co., Vermont, USA, 14.ii.1970, collected on basidiomes of *Laetiporus sulphureus* by C. Parsons (3272 JFL). This larva was first described by Böving and Rozen (1962) based on 80 larvae collected with 16 adults from the same fungus species at Cabin John Bridge, Maryland, U.S.A.

Lasiodites picta (Macleay). Five larvae collected in rotten starfruit (*Averrhoa carambola* L., Oxalidaceae) at Drumsite on Christmas Island, 12.iv.1989 by J.F. Lawrence. A series of adults was also collected from this locality. The larva was also described by Hayashi (1978: p. 18, pls 1-2).

Aethinodes marmorata Blackburn. A number of adults and larvae from 5 km S by W of Millaa Millaa, Qld, 15.v.1980, Berlesate 674, rainforest, I. Naumann, J. Cardale.

Aethinodes calva (Olliff). Five larvae collected near Highlands Guesthouse, Norfolk Island, 9.iv.1984, from a pitfall trap baited with human faeces by J.E. Feehan.



Figs 15-22. Nitidulinae larval parts: (15-16) head, lateral: (15) *Phenolia grossa* (Fabricius); (16) *Lasiodites picta* (Macleay). (17-18) abdominal tergum IX showing urogomphi and pregomphi: (17) *Phenolia grossa*; (18) *Lasiodites picta*. (19-20) portion of left side of abdominal tergum V: (19) *Phenolia grossa*; (20) *Lasiodites picta*. (21-22) central section of abdominal tergum V: (21) *Aethinodes calva* (Olliff); (22) *A. marmorata* Blackburn.

Figs 23-28. Nitidulinae larval parts: (23-25) labrum-epipharynx: (23) *Phenolia grossa* (Fabricius); (24) *Aethinodes calva* (Olliff); (25) *Lasiodites picta* (Macleay) turned right 90º. (26-28) mandibles: (26) *Phenolia grossa*, left mandible, dorsal; (27) same, ventral; (28) *Lasiodites picta*, right mandible, dorsal.

Larval differences between *Phenolia* and the above members of the *Aethinodes* group include the following;

1. Head of the *Phenolia* larva bears a strong median frontal protuberance (Fig. 15 and Böving and Rozen 1952, fig. 51); this is absent in *Aethinodes* larvae, while the head of *Lasiodites picta* (Fig. 16 and Hayashi 1978, figs 1e, 1g) has a pair of weak prominences.

2. Sensorium on antennomere 2 in *Phenolia* is about 0.2 times as long as antennomere 3, while it is at least 0.33 times as long in the *Aethinodes* group.

3. Larval labrum in members of the *Aethinodes* group (Figs 24-25) is semicircular in shape with a continuous margin extending from one basal angle to the other; it is also more or less connate with the clypeal apex. In the *Phenolia* larva the strongly transverse labrum (Fig. 23) is curved at the sides but apically truncate and articulates with the clypeal apex.

4. Labral tormae in *Phenolia* (Fig. 23) are long and parallel but in members of the *Aethinodes* group (Fig. 24) they are shorter, weaker and connected to curved projections arising from a transverse labral bar.

5. Mesotergum, metatergum and abdominal terga I-VIII in *Phenolia grossa* are relatively simple, each with a pair of small, transversely oval paramedian sclerites bearing three well separated short setae (Fig. 19). In *Lasiodites picta* there are similar paired sclerites, each of which lies in front of a well developed trilobed process, with each lobe bearing a short seta (Fig. 20). In *Aethinodes calva* (Fig. 21) and *A. marmorata* (Fig. 22) there is a single strongly transverse, slightly sclerotised tergal plate on each segment, from which arise a number of short setae arising from short tubercles.

6. Outer edge of the larval mandible in *Phenolia* has a sharply defined boss at the base of the apical lobe (Figs 26-27). In *Lasiodites* (Fig. 28) there is a similar boss but less sharp and more rounded and in *Aethinodes* there is at best a slight bulge at this point.

7. Inner edge of mandible in *Phenolia* (Figs 26-27) has an apical lobe with both dorsal and ventral serrations and a prostheca bearing several (usually fewer than 10) relatively short, curved spine-like processes with a blunt edge and without a fringe lining. In *Lasiodites* (Fig. 28) the apical lobe has dorsal serrations only and the spine-like processes of the prostheca are longer, more numerous, narrowly acute and have a fringe on the mesally facing edge. *Aethinodes* larvae are similar in having dorsal serrations and more numerous, acute spine-like processes, usually bearing fringes.

8. Spiracular tubes in *Phenolia* are much shorter than wide, forming a sclerotised ring only slightly longer on one side, so that it barely projects from the surface. In all members of the *Aethinodes* group the tubes are at least as long as and usually longer than wide, projecting well away from the surface, those towards the posterior end of the body more or less skewed posteriorly.

9. Urogomphi in *Phenolia* (Fig. 17) are separated by 1.2 times basal width and lack accessory tubercles. In *Lasiodites* (Fig. 18) the urogomphi are separated by 0.65 times basal width and bear several setose tubercles. The *Aethinodes* urogomphi are narrowly separated with similar setose tubercles.

Discussion

I think it is obvious from the above that both larvae and adults of *Phenolia grossa* differ in a number of respects from those of *Aethinodes* and its relatives. It is also obvious that Kirejtshuk and Kvamme (2002) made no attempt to diagnose the genus *Phenolia* sensu lato including *Aethinodes*, *Lasiodites* and *Plesiothina*, or to compare it with other possibly related Nitidulinae or include it in a phylogenetic analysis. If this latter group represents a single genus, then the oldest name would be *Aethinodes* Blackburn, 1891. Until this group is restudied, I prefer to recognise all three

genera. The informal *Phenolia* complex (Kirejtshuk 2008), which also includes *Stelidota* Erichson, *Gaulodes* Erichson, *Ussuriphila* Kirejtshuk and *Ostomarcha* Kirejtshuk, might be a natural group, but no set of characters has been given to define it or other apparent "complexes".

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A NEW SPECIES OF *CALOMELA* HOPE IN SOUTHEASTERN AUSTRALIA AND VALIDATION OF THE GENERIC NAME (COLEOPTERA: CHRYSOMELIDAE: CHRYSOMELINAE)

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Abstract

A new species of the leaf beetle genus *Calomela* Hope, 1840, is described from southeastern Australia: *Calomela moorei* **sp. n.** This has previously been confused with the southwestern Australian *C. maculicollis* (Boisduval, 1835). A neotype is designated for the latter to fix its identity. The two species are distinguished from all others in the genus and illustrated. The case for validity of the name *Calomela* over its objective senior synonym, *Australica* Chevrolat, 1836, is presented and the latter is discarded as a *nomen oblitum*.

Introduction

The cosmopolitan leaf beetle subfamily Chrysomelinae shows greatest diversity in Australia, where there are 43 genera and an estimated 775 species (Reid 2006, 2017, Reid *et al*. 2009). *Calomela* Hope, 1840 is a moderately large chrysomeline genus with 42 described species in Australia and three in New Guinea (Reid 2006). About 25% of *Calomela* species have recorded hosts and all are acacias (Reid 1989, 1992, 2006, Hunt *et al*. 1996, Jurado-Rivera *et al*. 2009).

Stabilisation of the generic name and its application

Calomela has been a stable name for over 130 years but that stability has been threatened by the discovery of the availability of the older name *Australica* Chevrolat, 1836, which is an objective senior synonym as both names have the same type species (Bousquet and Bouchard 2013). The name *Australica* was given priority (Baly 1855, 1856, 1863, 1865, Chapuis 1874) until Baly (1878) changed his mind and listed *Australica* as subordinate to *Calomela.* Since then, the name *Calomela* has stood and *Australica* has been ignored as a *nomen nudum* (Neave 1939, Reid 2006) or, when listed in catalogues, placed under *Calomela* (Weise 1916, Selman 1979, Seeno & Wilcox 1982, Daccordi 1994). The older name *Australica* has not been considered valid for more than 140 years, meeting the criterion of Article 23.9.1.1 (ICZN 1999). In that time the name *Calomela* has consistently been used as valid. In the last 50 years at least 25 works, published by at least 10 authors, have used the name *Calomela*, meeting the conditions of Article 23.9.1.2 (ICZN 1999): Andrew and Hughes 2007, Collett and Neumann 1995, Daccordi 1994, 2003, 2005, Daccordi and de Little 2003, de Little 2011, Hawkeswood 1994, Hawkeswood and Takizawa 2002, Hunt *et al.* 1996, Jolivet and Hawkeswood 1995, Jurado-Rivera *et al*. 2009, Lawrence and Britton 1991, Lawrence and Ślipiński 2013, Matthews and Reid 2002, Reid 1989, 1992, 2006, Reid and Berti 1992, Seeno and Wilcox 1982,

Selman 1975, 1976, 1977, 1979, Selman and Lowman 1983, Tan *et al*. 2017, van den Berg, 1982. We therefore fix *Calomela* Hope as a *nomen protectum* and the valid name for this entity and set aside the name *Australica* Chevrolat as a *nomen oblitum* (ICZN 1999: Art 23.9.2).

Until 1994, the name *Calomela* was applied to a group of chrysomeline species defined by presence of a deep hypomeral groove and possession of bifid tarsal claws (Selman 1979). Claw morphology was one of the key attributes in the tribal classification of the Chrysomelinae (Chapuis 1874) and therefore was used to distinguish genera (Selman 1977, 1979), although Selman was not consistent in his use of this feature. The significance of claw shape was queried in a comparison of two putative sister species, which had two different claw types (Reid 1992). Daccordi (1994) was the first to place all of the taxa with different claw types under one name, *Calomela*, but he did not provide any justification for that action. This reclassification of *Calomela* was supported in a morphological study of the Australian Chrysomelinae, which provided a diagnostic description of the genus (Reid 2006).

New species and dedication to Barry Moore

We are aware of at least 10 new or probably new species in *Calomela* in the Australian collections we have examined. Most of these require some critical examination of type material and most are in species complexes. However, two species have long been confused under the name *Calomela maculicollis* (Boisduval, 1835), which has hitherto been treated as a distinctive and widespread southern Australian species. One of these is new and we take the opportunity to describe this now, dedicating it to the late Barry Moore. In the 1970s Barry provided help and encouragement to CR when he was a keen amateur coleopterist in the UK, especially with regard to studying carabids, and he has long been grateful for that support.

Methods

All measurements were made with an eyepiece graticule. The photographs were imaged using a Leica MZ16 A then processed with the Leica Application Suite V3. Authors for host plant species can be found in the Australian Plant Name Index (Anonymous 2018).

Abbreviations: AMS – Australian Museum, Sydney; ANIC – Australian National Insect Collection, Canberra; NHML – Natural History Museum, London; SAM – South Australian Museum, Adelaide. Ratios and measurements: LW – body length:body width; LH – body length:body height; IO – interocular distance; HW – head width; EW – eye width; PW – pronotum width; PL: pronotum midline length. An asterisk indicates the specimen has been dissected. Label data have been reformatted to ‘locality, biological data, date, collector’

Species descriptions

Calomela maculicollis (Boisduval, 1835)

(Figs 1-2, 5, 7-8, 11, 13, 15)

Chrysomela maculicollis Boisduval, 1835: 578.

Australica maculicollis: Baly 1856: 246.

Lamprotoptera maculicollis: Motschulsky 1860: 217.

Calomela maculicollis: Lea 1902: 412.

Type material examined. Neotype ♂* (here designated), WESTERN AUSTRALIA: Deepdene, Karridale, 13.v.1963, LM O'Halloran / Neotype *Chrysomela maculicollis* Boisduval 1835 des. Chu & Reid 2018 / (ANIC).

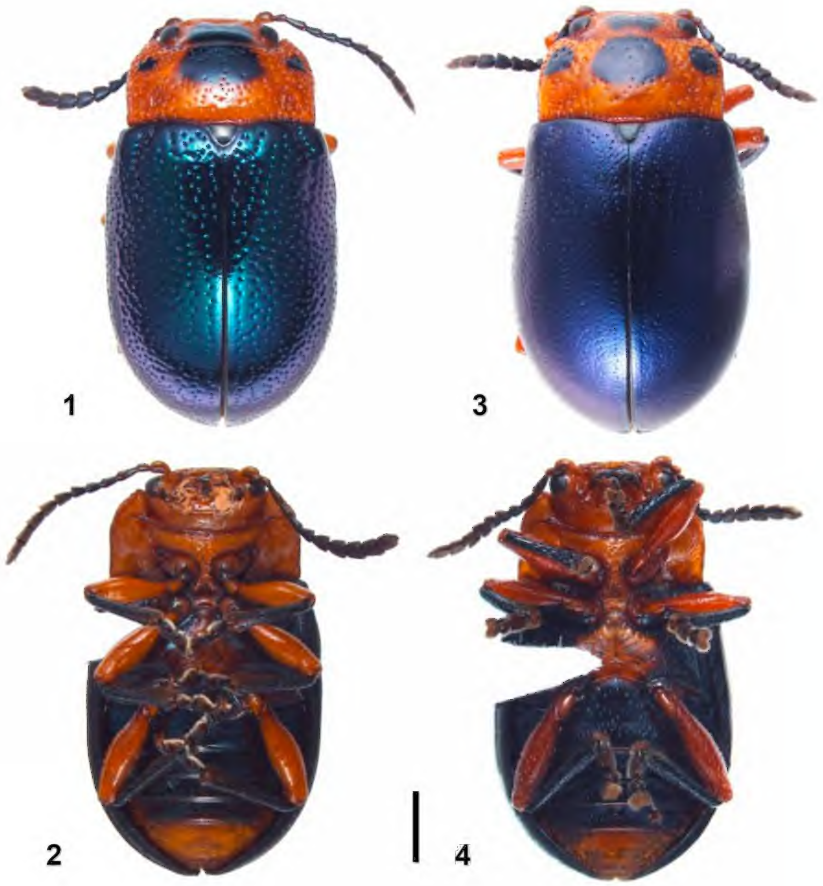
Other material examined. VICTORIA: 1, Melbourne (NHML) [mislabelled?]. WESTERN AUSTRALIA: 1, no locality, du Boulay (NHML); 2, Albany, Brewer (NHML); 1 ♀, Applecross, 24.vi.1975, FA Uther-Baker (ANIC); 1, Deep Dene, 23.xi.1963, L.M. O'Halloran (NHML); 1, Flinders Bay, 12.iv.1936, A.L. Raymond (NHML); 1 ♂, 1 ♀*, K G Sd [King George Sound], KK Spence coll (AMS); 1 ♀, Lake Muir, 60 km SE Manjimup, berlesate rotted cones *Macrozamia riedlei*, 6-10.vii.1980, S & J Peck (ANIC); 1, Swan R ex coll. Laferte (NHML); 1, Yanchep, 32 km N Perth, 1-7.i.1936, R.E. Turner (NHML).

Description. Length: male 5-6 mm (neotype 5.3 mm), female 6-7 mm. Ratios: male: LW 1.7-1.8, LH 2.4-2.6; female: LW 1.7-1.9, LH 2.4-2.7. Head, pronotum and elytra finely micropunctate but not microreticulate; venter microreticulate at sides of metaventrite and abdominal ventrites.

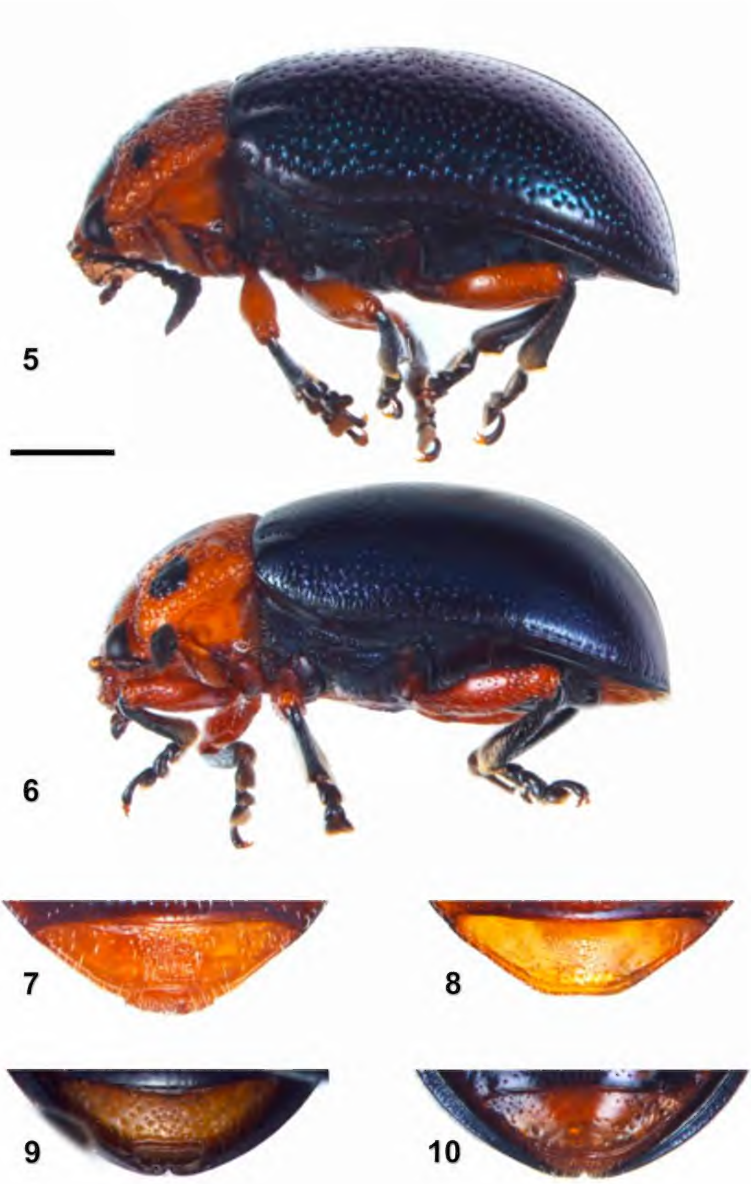
Colour: head capsule (except middle of vertex), labrum, prothorax (except three spots), mesoventral process, middle of metaventrite, pro- and mesocoxae, trochanters, femora and ventrite V, reddish orange; antennomere 1 mostly reddish orange but with black spot on each side, antennomeres 2-4 increasingly darker, 3-4 only have narrow edge reddish brown; antennomeres 5-11, palpi, middle of vertex, anteromedian portion of pronotum, sides of pronotal disc, scutellum, sides of meso- and metaventrites, lateroventral pterothoracic sclerites, tibial outer margins and tarsi, abdominal ventrites I-IV, black to bluish black; elytra bluish black with epipleura and scutellum brownish black.

Head: ratios: male: IO:HW = 0.6-0.7, IO:EW = 3.2-3.3, HW:PW = 0.6-0.7; female: IO:HW = 0.6-0.7, IO:EW = 3.4-3.8, HW:PW = 0.6-0.7. Eyes laterally prominent but small, head strongly contracted posteriorly; head deeply depressed along inner margin of eyes with outer edge of groove sharply defined and extending anteriorly and posteriorly beyond eye; frontoclypeal suture deeply depressed except at sides; anterior of clypeus elevated before anteclypeus but anterolateral corners depressed; frons with short and shallow median groove from frontoclypeal suture; ventral margin of eye with sharp transverse ridge almost reaching raised edge of mouth

cavity; sculpture of dorsal surface of head: strongly and closely punctate anteriorly and at sides with some punctures confluent (interspaces 0-1.5 puncture diameters), in contrast to sparser and finer discal puncturation (interspaces 1-4 diameters); antennae short, about half body length, antennomeres 2-11 dorsoventrally flattened, 2-5 elongate and narrow, 6 slightly elongate but strongly expanded to apex, 7-10 expanded and slightly transverse, width approx. 1.2x length, 11 expanded but elongate; antennomeres 1-5 shining and sparsely setose, 6 similar but densely setose on inner margin, 7-11 dull and densely setose.



Figs 1-4. *Calomela* species, habitus and venter: (1-2) *C. maculicollis* (Boisduval, 1835); (3-4) *C. moorei* **sp. n.** Scale bar = 1 mm.



Figs 5-10. *Calomela* species: (5) lateral of *C. maculicollis* (Boisduval, 1835); (6) lateral of *C. moorei* **sp. n.**; (7-10) fifth ventrite: (7) male, (8) female, *C. maculicollis*; (9) male, (10) female, *C. moorei*. Scale bar = 1 mm (Figs 5-6).

Figs 11-14. *Calomela* species: (11) penis of *C. maculicollis* (Boisduval, 1835) dorsal and lateral, neotype; (12) penis of *C. moorei* sp. n., ventral and lateral, holotype; (13) spermatheca *C. maculicollis*; (14) spermatheca *C. moorei*. Scale bars = 1 mm (Figs 11-12) and 0.5 mm (Figs 13-14).

Thorax. Ratios: male: PW:PL = 1.9-2.1; female: PW:PL = 2.0-2.1. Pronotum strongly transverse, broadest in anterior half, with anterior angles strongly anteriorly projecting but rounded; anterior and lateral margins strongly bordered, posterior margin very finely bordered; sides of pronotum strongly and closely punctate with some punctures confluent (interspaces 0-2 puncture diameters), in contrast to disc with sparse and finer punctures (interspaces 1-4 puncture diameters); hypomeral groove arising from a deep pit at junction

with prosternum, deeply depressed at base, reaching about 1/2 hypomeron length, with shallow transverse wrinkles along edge; prosternum slightly raised at base of process, almost impunctate except basal margins and process, process shallowly longitudinally depressed, with scattered large punctures, apex abruptly laterally expanded with posterior margin shallowly concave; scutellum impunctate with rounded sides and apex; elytra short, slightly rounded at sides, broadest just posterior to base, combined apices rounded; strongly punctate (punctures larger than on pronotal disc), with distinct short striole and first stria, irregular second stria, but remainder of elytra largely non-striate with large and often laterally confluent punctures (interspaces 0-1 puncture diameters) but with smooth interspaces; smooth impunctate interval present at lateral margin of elytra separating outermost stria from elytral disc; base of stria 5 depressed; post-humeral depression absent; epipleuron impunctate, without fringe of setae; mesoventrite process with deeply concave apical margin; metaventrite sparsely punctate and setose (interspaces 3-4 puncture diameters); male first pro-, meso- and metatarsomere with rounded sides and ventral oval patch of spatulate setae; female first pro-, meso- and metatarsomere with almost straight sides and ventral surface entirely covered in simple setae, slightly diverging from midline; claws with large acute triangular basal tooth.

Abdomen: ventrites I-V with well-defined lateral ridge, with sparse setae and punctures tending to form an irregular transverse row at middle of II-IV; ventrite V with setae on sides, disc with circular patch of dense fine punctures and setae in both sexes, not depressed; apex of male ventrite V strongly bordered, without teeth, with broad and shallow emargination**;** apex of female ventrite V truncate, not emarginate; penis sinuate in lateral view with rounded apex, basal 3/4 parallel-sided in dorsal view, apical quarter abruptly attenuated to bilobed apex, venter with elongate membranous patch at middle; flagellum visible in repose, extending slightly beyond apex; vaginal palp one-segmented; spermathecal receptaculum J-shaped, with expanded apex, duct not coiled.

Taxonomy. Baly (1856) seems to have been the first author to confuse this species with specimens from eastern Australia but he made no mention of having seen type material. Selman (1979) noted two possible type specimens of *C. maculicollis* in NHML, both of which we have examined. One, from 'South Australia' is labelled 'type' in Baly's handwriting. This designation by Baly of material other than his own species was used by Baly to indicate a 'typical' specimen (Selman 1979). There is no indication on the labels that this specimen was from Boisduval's collection. Furthermore, this specimen can be rejected as a type because it does not fit the original description, which was for a species that is 'punctatissima', or very punctate (Boisduval 1835: 578). The specimen labelled by Baly as 'type' is the opposite of this, being relatively weakly punctate for a species of *Calomela* and this other species is described as new below. The second specimen listed by Selman is strongly

punctured and was from a French mid-nineteenth century collection. Laferte, or more correctly F. La Ferté-Sénectère (Horn and Kahle 1935), sold his chrysomelid collection in 1864 via Janson and Hamlet Clark to the NHML (Horn and Kahle 1935). There is, however, no indication on the labels of this specimen of *C. maculicollis* in the NHML that this was a Boisduval type. Since most Boisduval chrysomelid types are either missing or unrecognisable (due to a combination of no labels and Boisduval's notoriously poor descriptions), we believe that the most practical option in this situation is to designate a neotype, as listed above under material examined. The neotype that has been chosen matches the original description.

Distribution and biology. *Calomela maculicollis* is found in far southwestern Australia. The single specimen we have seen from southeastern Australia (Victoria) is from an old collection and is likely to be mislabelled. Host plants are unknown for this species but are almost certain to be acacias. The label data suggest that this species has two generations per year, with active adults in midwinter and midsummer.

***Calomela moorei* sp. n.**

(Figs 3-4, 6, 9-10, 12, 14-15)

Types. Holotype ♂*, AUSTRALIAN CAPITAL TERRITORY: Bulls Head, Brindabella Ra, 35.23S 148.48E, 1330 m 55H0663807-6082544 GPS#175 *Ac. dealbata,* 4.xi.2005, Jurado & Reid (AMS). *Paratypes* (48): AUSTRALIA: 1 ♀, no data (AMS); AUSTRALIAN CAPITAL TERRITORY: 1 ♀, Black Mtn, on *Acacia*, 19.i.1976, P Carne (ANIC); 1, Black Mtn, *Acacia*, 22.x.1990, C. Reid (AMS); 1 ♀, Bulls Head, Brindabella Range, 35.23S 148.48E, *Acacia dealbata,* 4.xi.2005, J Jurado & C Reid (AMS); 1 ♀, Cotter, 13.iii.1976, D Ferguson (ANIC); 2 ♂♂, 2 ♀♀, Mulligans Flat, Gundaroo Rd, xii.1980, KR Pullen (ANIC); 1 ♂, Wombat Ck, 6 km NE Piccadilly Circus, 35.19S 148.51E, 750 m, ix.1984, Weir, Lawrence & Johnson (ANIC). NEW SOUTH WALES: 1 ♀, Bogalong (AMS); 1 ♀, Congo, 35.58S 150.09E, 22.xii.1983, M.S Upton (ANIC); 1 ♀, 4 km E Conjola 35.13S 150.27E, 2.x.1971, Z Liepa (ANIC); 1 ♂, Dorrigo (ANIC); 1 ♀, Eastwood, Armidale, ii.1980, SC Cairns (ANIC); 1 ♂, Galston Dumbrell, no data, AH Elston coll (AMS); 1 ♂, Hawkesbury R, EW Ferguson coll (ANIC); 1 ♀, Inverell, 7.ii.50 (AMS); 1, Killara, 9.ix.1945, N. Kent (NHML); 1 ♀, Kurrajong, x.31, Dr KK Spence (AMS); 1 ♀, London Foundation, Kioloa, feeding on leaves of *Ac. mearnsii*, J Conran (ANIC); 1 ♀, Macleay River (AMS); 1 ♂, Mt Allyn, 27.i.1975, CE Chadwick (ANIC); 1 ♀, Mt Kaputar Nat. Pk. 11-13.xi.1979, NW Rodd (AMS); 1 ♂, Narrabeen, EW Ferguson coll (ANIC); 1 ♀, nr Oldfields Hut, 36K N Adaminaby, 36.41S 148.46E, 24-28.xii.1993, J Balderson, PK Christensen (ANIC); 1 ♀, 4 km NE Paddys Riv., 30.i.1970, S Misko (ANIC); 1 ♀, 11 mi E Queanbeyan 11.ix.1957, Carne, Helman, Munro (ANIC); 1 ♀, Sawpit Ck, 7 km W Gundaroo, open scrub, *Ac. dealbata*, 30.xii.1984, C Reid (ANIC); 1 ♂, Sydney, ex Macleay Museum (ANIC); 1 ♀*, Tubrabucca, Upper Hunter Dist. 11.i.1948, A Musgrave & AM Party (AMS); 1 ♀*, Ulong, East Dorrigo, W Heron (AMS). QUEENSLAND: 1 ♂, Milmerran, xi.1950, JMC (ANIC). SOUTH AUSTRALIA: 1, no locality details (NHML). TASMANIA: 1 ♀, no data, Simson, Fry coll, ex BMNH (ANIC); 1 ♀, no data, EW Ferguson coll

(ANIC); 1 ♀, 6 mi SW Bicheno, 19.i.1948, Key, Carne & Kerr (ANIC); 1 ♂, Derwent Valley, *A. dealbata* (ANIC); 1, Eaglehawk Neck, 23.xi.1922 (NHML); 1 ♀, Florentine Vy, Bregawn Rd, 18.ii.1980, L Hill (ANIC); 1, Launceston (NHML); 1 ♂, 1 ♀, Liffey Valley, 1.viii.1984, S Fearn (ANIC); 1 ♀, Liffey Valley, 29.xi.1980, S Fearn (ANIC); 1 ♂, SW Tas, 42.43S 145.48E, 16.ii.1978, L Hill (ANIC). VICTORIA: 1 ♀, Beaconsfield, ii.1930, FEW (ANIC); 1 ♀, Mt Dandenong, 30.xii.1962, PG Kelly (ANIC); 1 ♀, Merrijig, 27.i.1964, PG Kelly (ANIC); 1, Sassafras (NHML).

Description. Length: male 4.5-5.5 mm (holotype 4.5 mm), female 6-7 mm. Ratios: male: LW 1.7-1.9, LH 2.5-2.7; female: LW 1.7-1.9, LH 2.4-2.7. Head, pronotum and elytra finely micropunctate but not microreticulate in males or head and pronotum microreticulate in females; elytra microstrigose between punctures; venter transversely microreticulate at sides of pterothorax and whole of abdominal ventrites.

Colour: head capsule (except middle of vertex), labrum, prothorax (usually except three spots), mesoventral process, middle of metaventrite, pro- and mesocoxae, trochanters, femora and ventrite V, reddish orange; antennomere 1 mostly reddish orange but with black spot on each side, antennomeres 2-4 increasingly darkened so that 3-4 only have narrow edge reddish brown; antennomeres 5-11, palpi, middle of vertex, anteromedian portion of pronotum (usually), sides of pronotal disc, scutellum, sides of meso- and metaventrites, lateroventral pterothoracic sclerites, tibiae and tarsi, abdominal ventrites I-IV, black to bluish black; elytra bluish black and scutellum contrastingly brownish black. The anteromedian pronotal spot can be narrowly divided along the midline or absent.

Head: ratios: male: IO:HW = 0.6-0.7, IO:EW = 3.3-3.5; HW:PW = 0.7-0.8, female: IO:HW = 0.6-0.7, IO:EW = 3.7-4.0, HW:PW = 0.6-0.7. Eyes laterally prominent but small, head strongly contracted posteriorly; head deeply depressed along inner margin of eyes with outer edge of groove steep but not sharp and not or only slightly extending anteriorly and posteriorly beyond eye; frontoclypeal suture deeply depressed except at sides; anterior of clypeus elevated before anteclypeus but anterolateral corners depressed; frons with short and shallow median groove from frontoclypeal suture; ventral margin of eye with sharp transverse ridge almost reaching raised edge of mouth cavity; sculpture of dorsal surface of head: strongly and closely punctate anteriorly and at sides with some punctures confluent (interspaces 0-2 puncture diameters), in contrast to slightly sparser and finer discal puncturation (interspaces 1-4 diameters); antennae short, about half body length, antennomeres 2-11 dorsoventrally flattened, 2-5 elongate and narrow, 6 slightly elongate but strongly expanded to apex, 7-10 expanded and slightly transverse, width approx. 1.2x length, 11 expanded but elongate; antennomeres 1-5 shining and sparsely setose, 6 similar but densely setose on inner margin, 7-11 dull and densely setose.

Thorax. Ratios: male: PW:PL = 1.7-2.0; female: PW:PL = 1.8-2.0. Pronotum strongly transverse, broadest in anterior half or middle, with anterior angles strongly anteriorly projecting but rounded; anterior and lateral margins strongly bordered, posterior margin finely bordered; side and base of pronotum strongly and closely punctate with some punctures confluent (interspaces 0-2 puncture diameters), in contrast to disc with sparser and finer punctures, sometimes only micropunctate (interspaces 1-6 puncture diameters); hypomeral groove arising from a deep pit at junction with prosternum, deeply depressed at base, reaching less than 1/2 hypomeron length, with shallow transverse wrinkles along edge; prosternum slightly raised at base of process, almost impunctate except basal margins and process, process shallowly longitudinally depressed, with scattered large punctures, apex abruptly laterally expanded with posterior margin shallowly concave; scutellum impunctate with rounded sides and apex; elytra short, slightly rounded at sides, broadest half to two-thirds length from base, combined apices rounded; relatively finely and shallowly punctate (punctures much smaller than on sides of pronotum), variable in distribution, from striole and first two striae distinct and almost regular with other striae partly visible as irregularly doubled punctures, to irregular short striole, first stria and second stria, but remainder of elytra largely non-striate; punctures never laterally confluent (interspaces 0.5-2 puncture diameters) and interspaces microstrigose, this sometimes obscuring punctures; smooth impunctate interval present at lateral margin of elytra separating outermost stria from elytral disc; base of stria 5 feebly depressed; post-humeral depression absent; epipleuron impunctate, without fringe of setae; mesoventrite process with shallowly concave apical margin; metaventrite sparsely and finely punctate and setose; male first pro-, meso- and metatarsomere with rounded sides and ventral oval patch of spatulate setae; female first pro-, meso- and metatarsomere with almost straight sides and ventral surface entirely covered in simple setae, slightly diverging from midline; tarsal claws with large acute triangular basal tooth.

Abdomen: ventrites I-V with well-defined lateral ridge, with sparse setae and punctures tending to form an irregular transverse row at middle of II-IV; ventrite V with sparse punctures and setae at sides, disc with closer stronger punctures in male or similar to sides in female, not depressed; apex of male ventrite V strongly bordered, without teeth, with broad and shallow emargination**;** apex of female ventrite V truncate; penis slightly curved in lateral view with acute apex, basal 3/4 parallel-sided in dorsal view but with slight constriction at middle, apical quarter gradually attenuated to narrowly truncate apex, venter membranous along midline for most of length; flagellum visible in repose, extending slightly beyond apex; spermathecal receptaculum U-shaped, cylindrical, duct not coiled.

Etymology. This species is named for the late Barry Moore, for his contributions to the knowledge of the Australian Coleoptera.

Taxonomy. *Calomela moorei* was previously confused under *C. maculicollis*, from Baly (1856) onwards, as noted above. Selman's key to the *Calomela* species with bifid claws (1979: 569) can be modified to include both species as follows:

20(19). Elytra uniformly dark blue, purple or black; pronotum and head orange-brown, except head usually with a large central and 2 smaller lateral spots black, head usually with a central black patch on vertex; venter of pterothorax and abdomen black, with middle of metaventrite and last abdominal ventrite orange-brown …….. 20a

– Elytra dark blue, green or purple, with the lateral margins brown; head, pronotum and venter brown (northwestern Australia) ….. …… *C. cingulata* (Baly, 1856)

20a(20). Elytra more finely punctate, discal punctures not confluent, smaller than largest pronotal punctures and intervals finely strigose; penis tip evenly attenuated to a blunt apex; ventrite V relatively sparsely punctured in both sexes, median area without dense patch of fine punctures and setae (southeastern Australia) ……..... *C. moorei* **sp. n.**

– Elytra more strongly punctate, discal punctures partly confluent, at least as large as largest pronotal punctures and with smooth interspaces; penis tip bilobed; ventrite V with dense finely punctured and setose median patch in both sexes (southwestern Australia) ….. …… *C. maculicollis* (Boisduval, 1835)

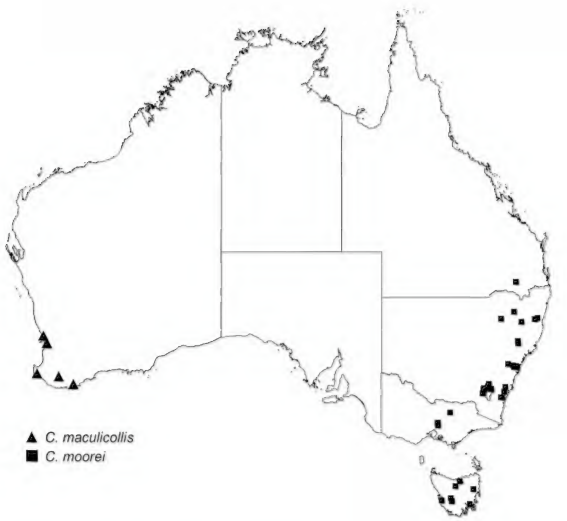


Fig. 15. Map of Australia, showing distribution of *C. maculicollis* (Boisduval, 1835) (▲) and *C. moorei* sp. n. (●).

Distribution and biology. Calomela moorei is found in southeastern Australia, particularly on the Dividing Range but also the coastal plains and western slopes, from south-east Queensland to Victoria. It is widespread in Tasmania and there is an old unlocalised record for South Australia that might be erroneously labelled. It is active in spring and summer and feeds on, or at least is associated with, *Acacia dealbata*, *A. decurrens, A. longifolia, A. mearnsii* and *A. paramattensis*, which are predominantly bipinnate acacias. In Tasmania, *Calomela moorei* is possibly part of a mimicry complex with the unusual coccinellid *Nat vandenbergae* Ślipiński 2007. There is a strong bias towards females in the material we have sexed (14 males, 31 females).

Acknowledgments

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ANOTHER MYSTERY LARVA: LARVAL SCAVENGING IN THE AMARYGMINI (COLEOPTERA: TENEBRIONIDAE: TENEBRIONINAE)

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Abstract

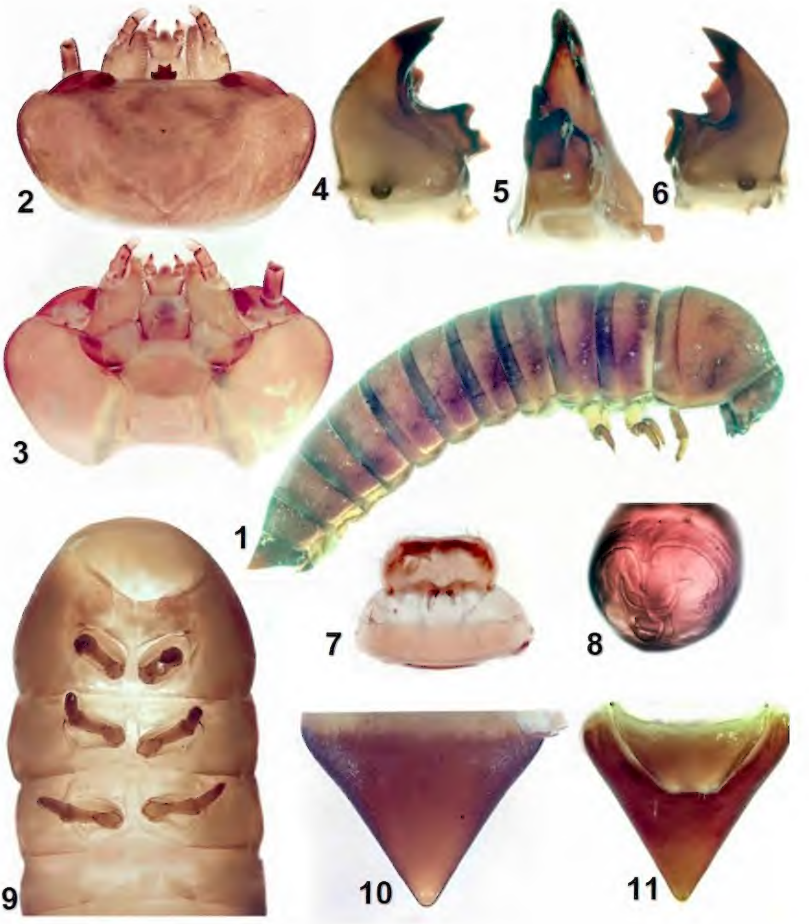
An unusual tenebrionid larva from Queensland associated with large black ants is described and compared with known larvae of various members of the tenebrionid tribe Amarygmini. Larval features suggest that this species is related to the genus *Chalcopteroides* Strand but differs significantly from larvae currently associated with that genus. This is the first amarygmine larva apparently associated with ants and this larva, plus those of at least two species of *Chalcopteroides*, are either scavengers or predators, unlike previously known xylophagous or phytophagous larvae in this tribe.

Introduction

Among Barry Moore's lesser-known activities was the rearing and identification of beetle larvae and during his career he preserved and identified many larvae belonging to his favourite family, the Carabidae. The most unusual of these was collected by him in 1969 in the vicinity of Hattah Lakes in western Victoria. Although definitely a carabid, this larva had many distinctive features, including very short antennae with a highly reduced terminal antennomere, inflated labial palps and a complete absence of urogomphi. One of us (JFL) found in the Australian National Insect Collection a similar but much larger larva collected many years previously at Yass, New South Wales. Subsequent pitfall collections, primarily from western Victoria and New South Wales, South Australia and the Australian Capital Territory, produced several other larvae of this type but varying in size, colour and other details. The identity of these larvae was finally solved during an ANIC expedition to Brookfield Conservation Park in South Australia, when adults of two species of the scaritine carabid genus *Carenum* Bonelli, isolated in containers with sand and larval prey, produced eggs and then larvae of the same type. Based on the structure of these larvae (which differed significantly from those of other known scaritine larvae) and correlated differences in adult structure, the genus *Carenum* and several related Australian taxa were placed in a distinct tribe Carenini (Moore and Lawrence 1994).

It seems fitting in a memorial volume for Barry to describe another unusual beetle larva but in this case without the benefit of rearing to the adult stage. A single specimen of this unusual larva (Fig. 1) was found by Jack Hasenpusch in the Forty Mile Scrub, northern Queensland, beneath a log in the company of large black ants. The collector had not identified the ants but informed JFL that the larva had been encountered a couple of times over the years, each time when rolling a log. They were apparently just at the entrance of the ant

nest and would quickly move into the burrow when disturbed, making collecting difficult. The larva was photographed, examined superficially and then dissected. The surface of the larva was partly covered by a slimy substance and when the gut was removed it contained a number of arthropod parts, including at least one ant head and an intact small spider, mixed with a similar slimy substance.



Figs 1-11. Unidentified amarygmine larva: (1) lateral; (2) head with clypeus, labrum, mandibles and left antenna removed, dorsal view; (3) head with clypeus, labrum and mandibles removed, ventral view; (4-6) mandibles: (4) right, ventral, (5) left, mesal, (6) left ventral; (7) clypeus and labrum-epipharynx, ventral; (8) antennal apex; (9) thorax and first abdominal segment, ventral; (10) abdominal tergum IX, dorsal; (11) same, ventral.

The larva appears to be either a scavenger or predator. The partly dissected larva was then compared with known larvae in the Australian National Insect Collection in Canberra. A careful examination of various features confirmed that it must belong to the family Tenebrionidae and, among known Australian tenebrionid larvae, it most closely resembles some members of the genus *Chalcopteroides* Strand (Tenebrioninae: Amarygmini), although differing in some respects as indicated below.

Description

Length 26 mm; body (Fig. 1) widest at level of metathorax and slightly, gradually narrowed anteriorly and posteriorly, with strongly convex dorsum and flat venter; upper surfaces primarily reddish brown, with posterior, transverse striated bands on most body segments dark brown and anterior transverse bands (when exposed) yellow; undersurface of head yellow, except for gula, which is cream; anterior concealed portions of meso- and metaterga and abdominal terga I-VIII yellow, inflexed laterotergites brownish yellow with darker markings and most abdominal sterna cream to yellow; legs with coxae cream, trochanters yellow and remaining segments brown.

Head (Fig. 2) 0.6 times as long as wide, widest at anterior third, strongly convex and distinctly declined beyond vertex; sides of head strongly rounded; stemmata consisting of two tight groups of small eye spots, anterior one just behind antennal insertion and second one well behind this and more dorsally located; epicranial stem about 0.05 times as long as head width; frontal arms more or less U-shaped, each divided at anterior third, with lateral fork extending to antennal articulation and mesal fork extending anteromesally to frontoclypeal suture, which is complete and distinct. Frontal region on either side of clypeus forming a moderately well sclerotised supra-antennal ridge concealing the antennal insertions from above. Clypeus 0.45 times as long as wide, with sides strongly converging and apex truncate; darker postclypeus 1.50 times as long as lightly pigmented anteclypeus, the former with two pairs of moderately long setae, one near anterolateral corners and another on each side of disc at lateral fifth. Labrum about 0.47 times as long as wide, with sides slightly rounded and apex truncate, bearing 8 marginal setae (2 lateral, 4 anterolateral, 4 anterior median) and 2 more on disc; base with broad transverse bar bearing a pair of asymmetrically triangular processes near lateral edge, a pair of lightly sclerotised, slightly curved tormae at lateral third and a pair of short, subtriangular anterior projections just mesal to tormae.

Epipharynx (Fig. 7) with 3 stout anterolateral submarginal setae on each side, 4 finer anterior submarginal setae, a transverse submarginal patch of short microtrichia, two curved, longitudinal microtrichial patches (chaetoparia) flanking central space (pedium), with moderately long microtrichia mesally grading laterally into very short microtrichia and broad patches of finer tubercles. Pedium with an irregular and widely separated group of 6 anterior

trichoid sensilla, a transverse row of 4 smaller sensilla at about middle, a pair of large trichoid sensilla at posterior end and a background of relatively dense minute pegs grading into fine microtrichia anteriorly. Haptolachus with two nesia (Böving 1936), the right one longer and attached to an elongate comb of stout teeth, the left one shorter and attached to a few stout teeth and the area between with an irregular cluster of small, trichoid sensilla; area lateral to each nesium with an elongate setal fringe.

Antenna about 0.15 times as long as head width; its articulation separated from mandibular attachment by very thin strip of cuticle; first antennomere 0.63 times as long as wide; second 1.83 times as long as wide, subcylindrical and 2.36 times as long as first, its apex with large sinuous sensorium (Fig. 8) 'M'-shaped and partly enclosing minute third antennomere.

Mandibles (Figs 4-6) heavily sclerotised, about 1.25 times as long as wide; outer edge of each somewhat flattened; apex unidentate, but with 2 subapical ridges, each bearing a tooth, the ventral one closer to the apex than the dorsal one. Molae sub-basal and asymmetrical, the left one irregularly subquadrate and concave, with sharp dorsal and ventral ridges and a rounded, apicoventral projection, the right one convex and transversely subdivided by ridge. Ventral mouthparts only slightly retracted (distance between the mandibular and maxillary articulations about 0.65 times mid-width of the stipes) and projecting forward almost to the mandibular apices; hypostomal ridges and hypostomal rods absent. Cardines each with darker, transversely semicircular posterior section and a lightly pigmented subtriangular anteromesal section, closely abutting the maxillary articulating area, which is longitudinally ovoid. Stipes 1.3 times as long as wide. Mala (Fig. 3) 1.36 times as long as wide, moderately broadly rounded at apex, with evenly spaced setae extending from apex along inner edge and onto stipes. Maxillary palp 3-segmented with well developed, articulated palpifer; ratio of palpomere lengths 1.33: 1.33: 1.00, the terminal palpomere conical.

Labium (Fig. 3) free to base of mentum. Submentum about 0.6 times as long as wide, distinctly widened from posterior edge to just beyond middle, then narrowed to apex, posterior portion heavily pigmented and bordered by longitudinal, oblique posterior tentorial pits, anterior portion lightly pigmented and abutting maxillary articulating area. Mentum 0.77 times as long as wide, 0.7 times as long as submentum, widest and more or less angulate at anterior third, with anterior portion more lightly pigmented. Prementum 0.5 times as long as wide and 0.5 times as long as mentum, widest at apex and bearing a broadly rounded ligula that is about as long as first labial palpomere. Labial palps separated by about 2.0 times the basal width of one; palpomere ratio 1.0: 1.1, apical palpomere slightly narrower, widest at base and slightly narrowed apically.

Hypopharyngeal sclerome (Fig. 2) divided into two sections with two anterolateral teeth on broader posterior section and two teeth at apex of

narrower anterior section. Gula distinctly separated from mentum, subquadrate, 0.5 times as long as wide, 0.72 times as long as submentum and very lightly pigmented.

Prothorax about 2.25 times the length of meso- or metathorax and about 0.8 times as long as wide; protergum strongly declined anteriorly, with transverse carina at posterior fifth separating evenly sclerotised anterior section from broad, longitudinally striate posterior band; sides strongly bent inwardly but not sharply carinate, so that main tergal plate not clearly separated from laterotergites on each side. Surface smooth and densely but somewhat unevenly covered with very fine, shallow, circular punctures, about 0.04 mm in diameter and barely visible at lower magnifications. Meso- and metathorax about equal in length and about 0.3 times as long as wide, each with narrower posterior band, their surfaces similarly punctured. Proventer (Fig. 9) with relatively large but vaguely defined laterotergites, reduced but clearly indicated pleural sclerites and a large median presternum partly divided longitudinally into four subquadrate sections, the lateral two darkly pigmented and the mesal two more lightly so. Procoxae separated by about 0.33 times shortest coxal diameter. Meso- and metaventra each with coxae separated by about 0.6 times the shortest coxal diameter. Mesothoracic spiracle about 0.06 times as long as thoracic width, 2.75 times as long as wide, transversely oriented, located at anterior edge of infolded laterotergite and usually concealed by posterior edge of prothorax. Legs moderately slender, more or less equal in length, about 0.6 times as long as thoracic width; coxae 1.7 times as long as wide, obliquely oval and slightly projecting; trochanters about a third as long; femur and tibiotarsus each about half as long as coxa and slender; pretarsus long, slender and acute. Coxae longitudinally carinate with a series of 6 stout setae along carina, trochanter, femur and tibiotarsus all clothed with short spines; pretarsus with 2 long, fine setae.

Abdomen about 1.67 times as long as thorax; terga I-VII more or less equal in length, VIII and IX each about 0.86 times as long as anterior terga: tergum I about 0.29 times as long as wide, terga II-VII each slightly less transverse, as segment widths decrease posteriorly; tergum VIII 0.43 times as long as wide and slightly narrowed posteriorly. Surfaces of abdominal terga similar to those on meso- and metaterga, with median punctate area, weakly defined anterior band (usually concealed by previous segment) and posterior transverse striated band delimited by a weak transverse carina, with a seta at each end. Sides of terga strongly evenly curved on each side and extending to a fine longitudinal line, where it sharply bends onto the ventral surface; the posterior end of this line meets the lateral end of the posterior carina. Spiracles occur just below this line at the anterior end of the segment (usually concealed by overlap of the previous segment). Anterior sterna relatively simple but sternum VII with patch of dark tubercles on each side and sternum VIII with similar but more extensive patches. Tergum IX 0.67 times as long

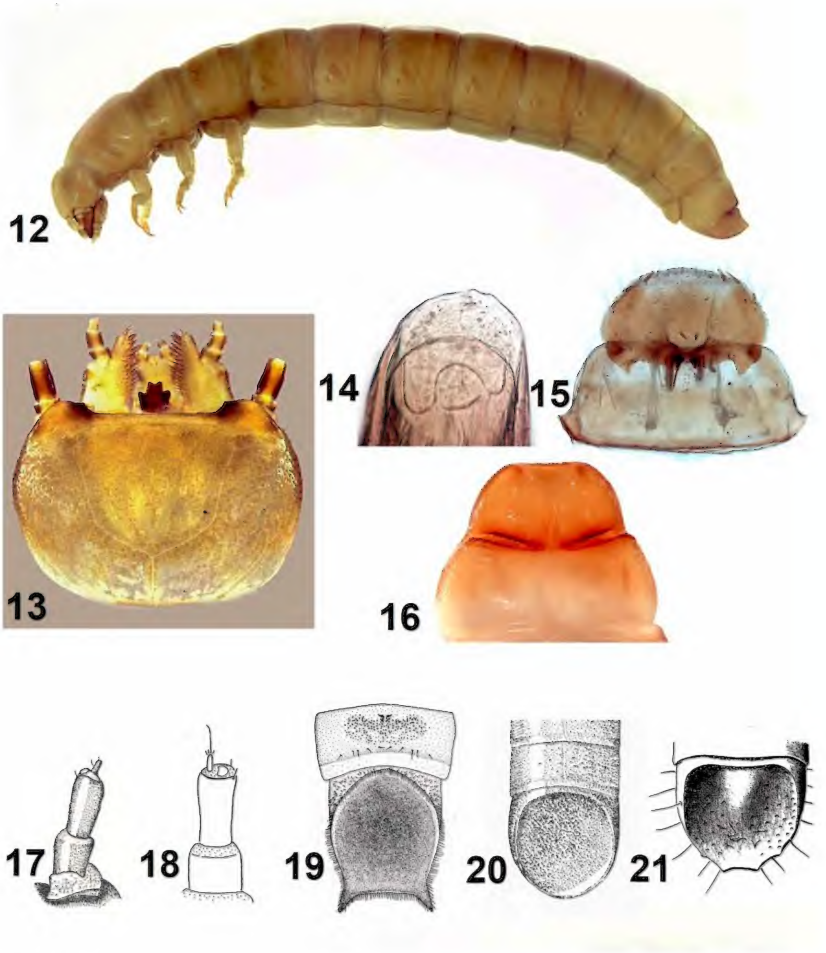
as wide, slightly longer than VIII, widest at base and subconical, with sides evenly converging to subacute, slightly curved, spout-like apex (Figs 10-11) and extending well onto ventral surface; sternum IX about 0.4 times as long as wide, trapezoidal, with relatively broad truncate apex, similar in colour to tergum IX. Segment X composed of a pair of ventral, flattened pygopods, closely appressed to sternum IX and probably not capable of being projected, and a subtriangular dorsal, lightly sclerotised lobe.

All spiracles annular, elongate-oval, about 3 times as long as wide, with simple peritreme. Thoracic spiracles 0.06 times as long as width of mesothorax; abdominal spiracles 0.03 times as long as abdominal width. No spiracles are exposed when the body segments are normally overlapping.

Discussion

There is little doubt that this larva belongs to the family Tenebrionidae, based on a suite of characters such as the lack of hypostomal rods combined with the presence of a frontoclypeal suture, simple mala, annular spiracles and more or less concealed tenth segment, except for protruding pygopods. In the world-based key by Watts (1974), the larva keys out in the last couplet (Amarygmini, Tenebrionini and some Cnodalonini) based on spiracles with simple, non-crenulate peritreme, antennal insertions and mandibular bases narrowly separated, tergite IX longer than sternite IX, so that anus not terminal, antennae not pubescent, forelegs not modified for digging, hypopharyngeal sclerome tridentate, without anterior extension and urogomphi absent. Amarygmine larvae are separated from members of the other two tribes in either lacking urogomphi (with an oval excavation on tergite IX) or with short urogomphi borne on an obliquely projecting process (the latter based on the larva of an Australian species of *Chalcopteroides*). All other previously described amarygmine larvae – *Amarygmus* Dalman (Hayashi 1966 as *Elixota* Pascoe, Spilman 1966), *Cymatosthes* Dejean (Spilman 1969, Costa *et al*. 1988), *Meracantha contracta* (Beauvois) (Hyslop 1915) and *Plesiophthalmus nigrocyaneus* Motschulsky (Hayashi 1966) – lack urogomphi and have a concave disc occupying most of tergite IX (Figs 19-21; in addition all have distinctly 3-segmented antennae, with a moderately well developed third antennomere (Figs 17-18).

Most Australian amarygmine larvae of this type are reddish brown in colour and feed in rotten wood but a variant of this is somewhat greenish when alive, with dark bands along the body and can be found at night feeding on bark (perhaps on algae or lichens). Both have been associated with adult *Amarygmus*. A second very distinct type of amarygmine larva is that mentioned by Watt (1974) and associated with a species of *Chalcopteroides* tentatively identified by Watt as *C. tinctus* Blackburn (Figs 12-16). The head in this larva is somewhat broader and flatter than the typical amarygmine, the antenna appears to be 2-segmented, with antennomere 3 reduced to a minute remnant partly enclosed by the sensorium (Fig. 14) and tergite IX has a deep



Figs 12-21. Amarygmine larvae: (12-16) *Chalcopteroides* sp. (Pine Hill Rock Hole, 18 km NWxN Mt Ragged, WA): (12) larval lateral; (13) same, head with mandibles, clypeus and labrum removed, dorsal; (14) same, antennal apex; (15) clypeus and labrum-epipharynx, ventral; (16) abdominal apex (tergum IX), dorsal. (17, 20) *Meracantha contracta* (Beauvois): (17) antenna; (20) abdominal apex, dorsal. (18, 21) *Amarygmus morio* (Fabricius): (18) antenna; (21) abdominal apex, dorsal. (19) *Cymatosthes nebulosus* (Fabricius): abdominal apex, dorsal. (Figs 17 & 20 from Hyslop 1915; 18 & 21 from Spilman 1966; 19 from Costa *et al.* 1988).

transverse groove behind which is a pair of globose projections, each with a small point at the apex (Fig. 16). This larval type has been found on several occasions but never in wood or on bark, rather under stones or other objects

on the ground. Furthermore the gut contents of one larva contained bits of arthropod cuticle, as in our mystery larva. Another larva with the same type of head and antenna displayed a conical tergite IX with two fine points at the apex and another formed an elongate, subconical process, broadly rounded at the apex. Adults reared from these specialised larval types appeared to be *Chalcopteroides*, although the separation of this genus from *Amarygmus* seems to be based only on the mandibular apex. Both of these genera are speciose in Australia (with 115 and 54 species respectively: Blackburn 1892, 1893, Carter 1913, Watt 1989, Matthews and Bouchard 2008) and an attempt to identify those species was considered beyond the scope of this study. What does appear to be clear is that all known *Chalcopteroides* larvae and the unusual larva described here are either scavengers or predators, unlike the xylophagous or phytophagous larvae previously described for members of this tribe.

There is little doubt that the mystery larva belongs in this complex but its somewhat slug-like shape, strongly transverse and laterally bulging hypognathous head, unique antennal sensorium and conical tergite IX, as well as its close association with ants, differ from the others mentioned above. Of the few other amarygmine genera known from Australia, *Isopteroplonyx termitophilus* (Lea) is a termitophile, *Trichamarygmus pilosus* Carter occurs in Western Australia and *Axynaon championi* Bates has a very restricted distribution and habitat in Queensland (Matthews and Bouchard 2008). According to Bremer and Lillig (2014) '… one should postpone final decisions about the taxonomic status of genera near *Chalcopteroides* Strand and of other genera until larvae of more species of these genera have been examined'. The species currently included in the genera *Amarygmus* and *Chalcopteroides* need further study, particularly with reference to larval habits.

Acknowledgments

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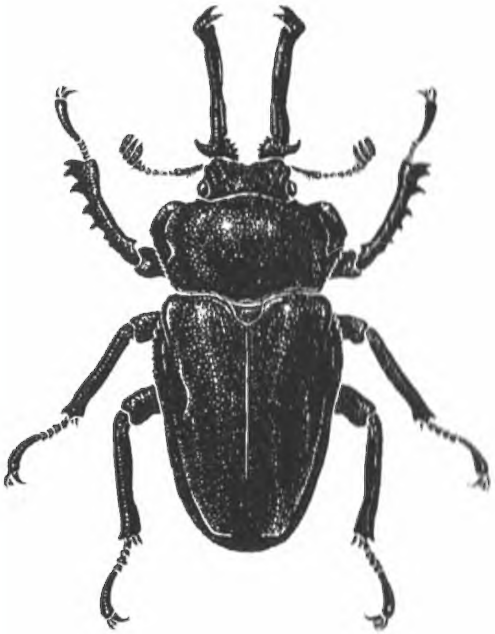

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COVER

The dragonfly, *Hemicordulia australiae* (Rambur), in the wheel position near a garden pond at Currimundi, on the Queensland Sunshine Coast. This species is widespread in Australia, the Lesser Sundas and New Zealand. At the stage depicted the male (top) has previously transferred his sperm from the testes at the tip of the abdomen to the seminal vesicle on the second segment near the base of the abdomen. The female has made genital contact forming the heart-shaped 'wheel', during which the male inseminates her. Pen and ink drawing by *Australian Entomologist* subscriber, Dr Albert Orr, whose illustrated books on dragonflies and butterflies have won awards in Australia and overseas.

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